TECHNOLOGY DEPT

Plastics

DEALING WITH THE MANUFACTURE, USES AND POTENTIALITIES OF PLASTIC MATERIALS

JUN 25 1956
DETROIT

KEEP UP-TO-DATE WITH BAKELITE PROGRESS

The object of 'Bakelite Progress' is to describe some of the latest applications for the wide range of BAKELITE Plastics. By showing how these materials are solving problems in a variety of industries, 'Bakelite Progress' may suggest new uses in your own field.

ARE YOU ON OUR MAILING LIST?

'Bakelite Progress' is published every few months. If you do not already see copies, please let us know.

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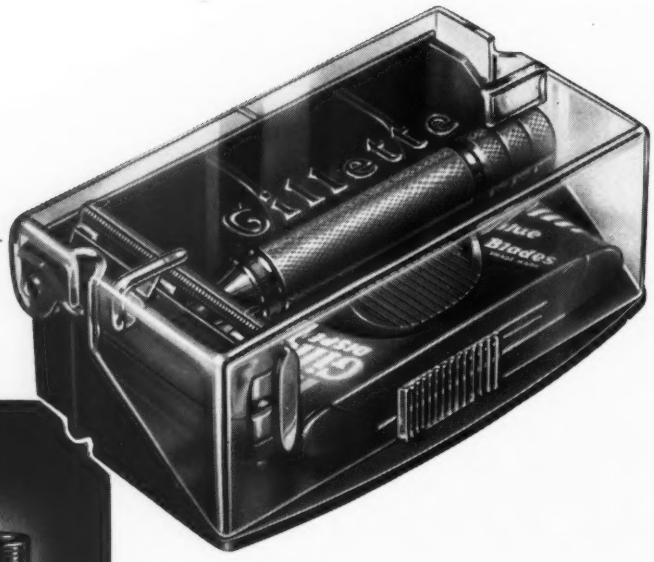
Bakelite Limited · 12-18 Grosvenor Gardens · London SW1 · SLOane 6855

Bextrene forms the case for the Gillette Rocket Razor set. Bextrene has an unlimited range of colours and designs, produces mouldings of great beauty and is dimensionally stable.



This Oil Bottle is moulded in Bexoid, a material which gives tough, non-splintering mouldings, capable of withstanding a wide range of temperatures and pressures.

The Tale of the ROCKET RAZOR *and the* OIL BOTTLE

Poles apart in many ways, yet both have one thing in common: the use of BX moulding powders in their construction. For the Rocket Razor set, Gillette Industries Ltd., needed a transparent, eye-arresting pack that would yet possess adequate strength and be cheap to produce. Bextrene, free flowing and ideal for large quantity production, is used for this moulding. The Oil Bottle moulded by E. Elliott Ltd. for Ernest Scragg & Sons Ltd., was required to be, above all, tough enough to stand up to a long life of heavy industrial use providing the large volume of oil needed by modern high speed twisting spindles; hence the choice of a one-piece moulding in transparent Bexoid.

If you have a problem concerning moulding powders — contact BX first

BX

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BEXOID REGD.

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Cut from sheet stock in one shearing action

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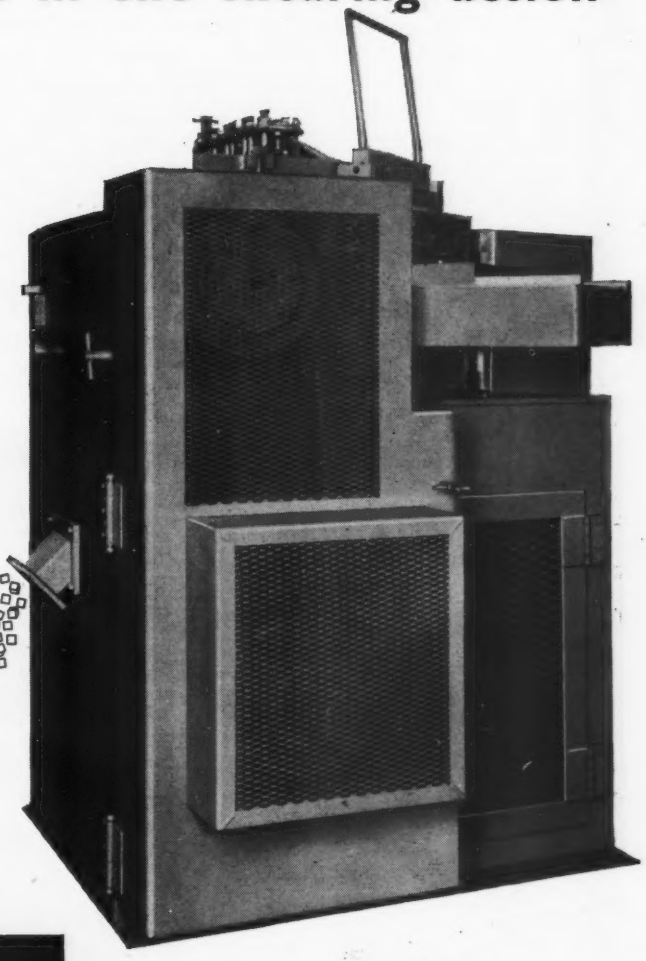
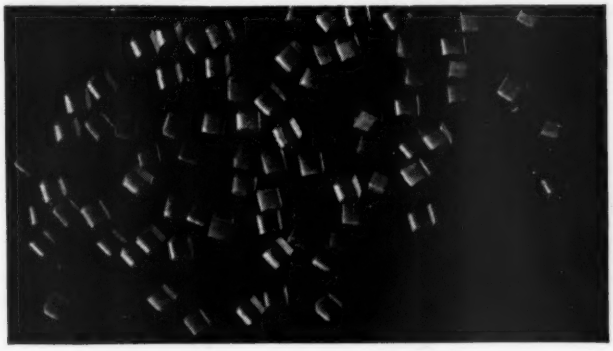
This new dicing principle makes it possible to dice the full range of plastic materials, including polyethylene, vinyl, acetate and nylon. Two standard machine sizes accommodate sheets up to 7 ins. or 14 ins. wide. Machines to handle greater widths can be specially built. Write for complete technical details.





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Manufactured under licence from Cumberland Engineering Company, Inc., United States

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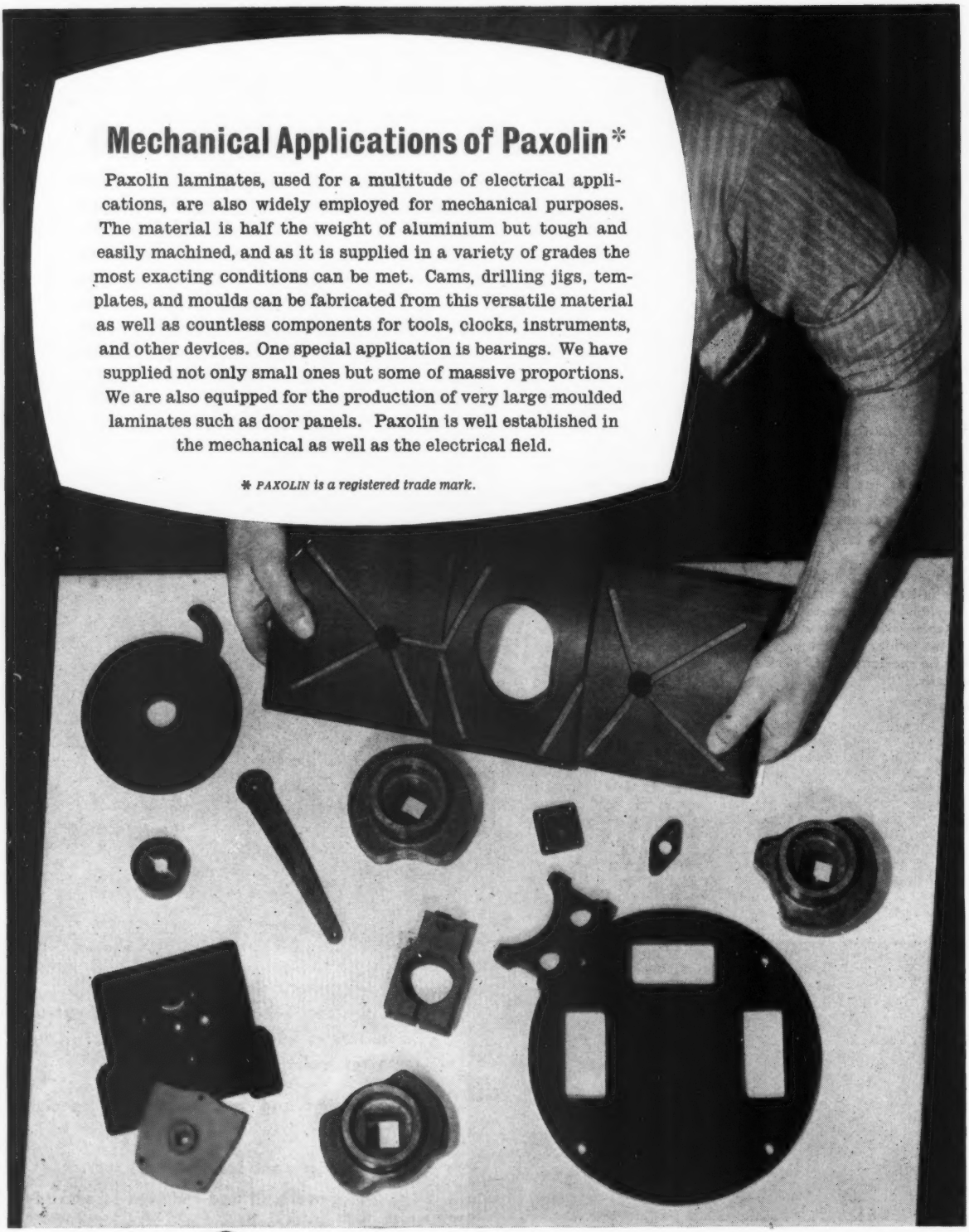
* *PAXOLIN is a registered trade mark.*



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STANDARD INJECTION MACHINES

MODEL NUMBER	150-H-6	300-H-12	400-H-20	800-H-48
Capacity (oz.–Single Feed)	6	12	20	48
Capacity (oz.–Double Feed)	8	16	28	64
Material Injected (cu. in. per min.)	440	1035	1330	2895
Plasticizing Capacity (lbs. per hour)	60	100	135	350
Mould Clamp Capacity (tons)	150	300	400	800
Mould Space (hor. × vert.):				
(a) Full Platen Vert.	10½″ × 25″	16½″ × 33″	20½″ × 42″	36″ × 54″
(b) Full Platen Hor.	20½″ × 15″	30″ × 20″	36″ × 26½″	54″ × 36″
Daylight Opening without Ram Spacer	20″	30″	40″	55″
Daylight Opening with Ram Spacer	16″	26″	34″	47″
Mould Thickness without Ram Spacer	10″	10″	15″	20″
Mould Thickness with Ram Spacer	6″	6″	9″	12″
Clamp Travel (max.)	10″	20″	25″	35″
Motor Horse-power	20	40	50	100
Shipping Weight (pounds)	14500	22000	39000	75000

NOTE: All ratings based on moulding general purpose polystyrene

Other H.P.M. Models are available with these capacities:—

STANDARD
Model 600-H-32 Capacity 32 ounces.
,, 1200-H-80 ,, 80/100 ,,

PRE-PLASTICIZING
Model 400-P48A Capacity 48 ounces.
,, 1200-P200 ,, 200 ,,
,, 3000-P400A ,, 400 ,,

INTERNATIONAL MACHINE TOOL EXHIBITION 1956
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From 6 ounces to 400 ounces; with mould clamping pressures from 150 tons to 3,000 tons . . . that's the scope of the new H.P.M. range.

Each machine is new, designed with many outstanding features. High capacity plasticizing chambers, weigh feeders, greater 'shot' capacities, increased daylight and stroke, quiet pumps, and sub-plate mounted valves reducing piping to the absolute minimum, are some of the reasons why H.P.M.'s mould better, faster and at lower cost.

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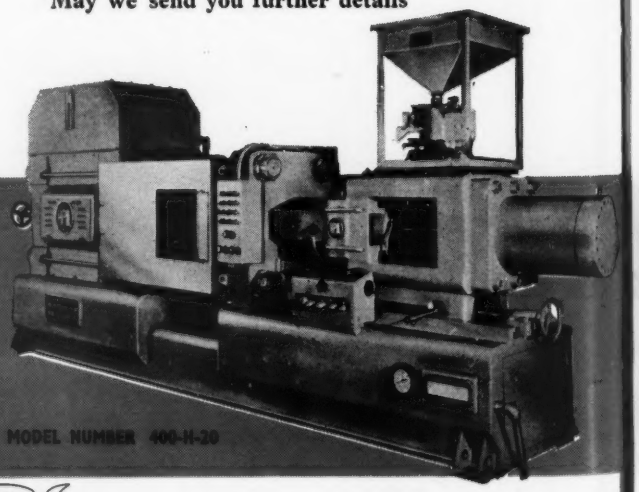
May we send you further details



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For further information and technical advice consult the IRIDON DIVISION of

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and a man's too!

More and more manufacturers are using 'Celastoid' sheet because . . .

Because **'Celastoid'** is easily formed and does not chip, snap or crack when machined.

Because **'Celastoid'** is ideal for high quality precision work and is used extensively for optical purposes, combining utility with beauty.

Because **'Celastoid'** is shatterproof and tough. For visors, goggles and other safety purposes it is unrivalled.

Because **'Celastoid'** comes in accurately gauged sheets of many colours. It can be laminated for two-tone effects.

Doll by Britannia Toy Company Limited.
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Dressing Table Set marketed by Rowland (Birmingham) Limited, Shenstone, Staffs. Incorporating 'Raymoloid' Decorated 'Celastoid' inserts.

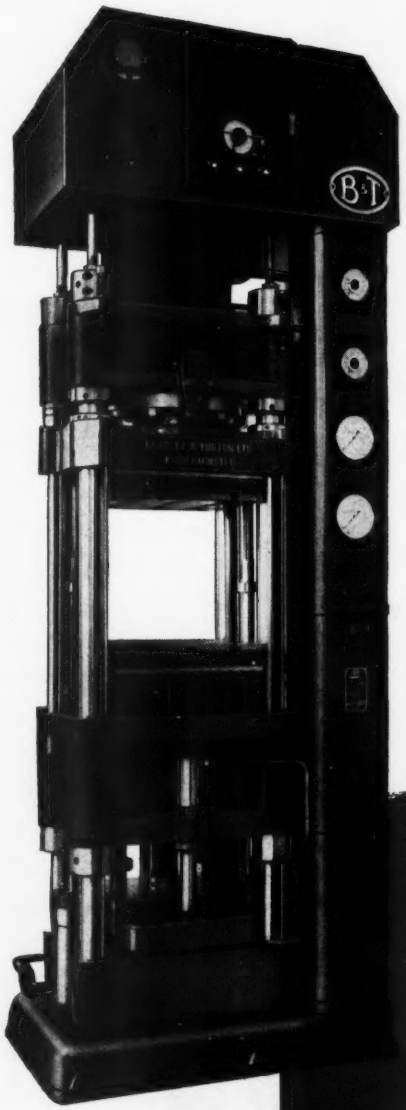
BRITISH CELANESE LIMITED

Plastics Division. Celanese House, Hanover Square, London, W.1. Mayfair 8000.

'536'

UNIVERSAL MOULDING PRESS

. . . with push-button automatic control!



Here in one compact self-contained unit is a new advance in precision engineered, auto-controlled moulding presses. The '536' repeats any thermosetting moulding cycle, transfer or compression, including "breathing" and "dwell" — automatically. The operator simply loads the powder and presses a button.

The '536' Type U/1 is fitted with its own motor driven pump unit and only requires the electrical connections to be made for starting up.

It can also be supplied to operate from an accumulator supply.

Changeover from one moulding cycle to another is simplicity itself and can be accomplished in minutes!

Hand operation is provided for tool setting and short run production.

Full details are available upon request. Please ask for leaflet No. 47/23.

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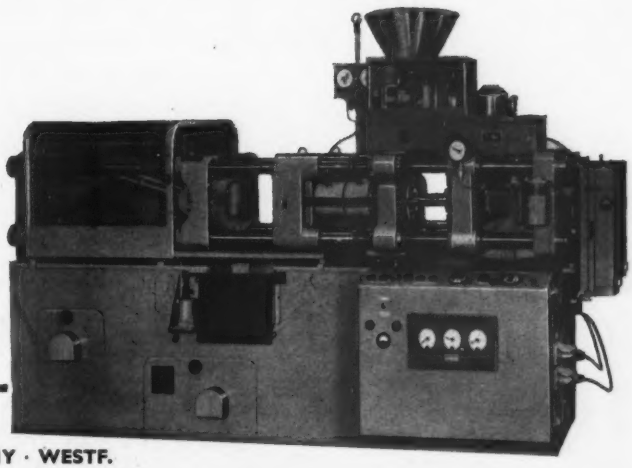
The BSM 100 S is especially economical in that it is directly connected to the electric supply. Energy consumption is only about 5 kW per hour.

BATTENFELD Injection Moulding Machines from ¼ to 50 ounces for thermoplastic materials.



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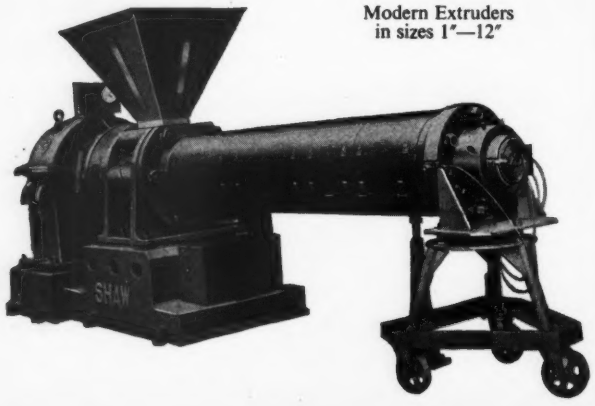
quality extrusions through controlled temperature zones

To produce quality extrusions without the risk of imperfection requires temperature control to a fine degree. These Shaw Extruders provide it exactly. There is all electric heating in separate zones and each zone is independently controlled by proportioning instruments.

Various screw and die designs are available for the production of piping, sheeting, miscellaneous sections, and the insulation and sheathing of cables, etc. Great attention has been paid to bearings and barrel support to avoid wear and vibration.



Modern Extruders in sizes 1″—12″

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RIL embossed

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This gay little apron is one of many articles produced by our customers from Rilprint printed P.V.C. Sheeting. Rilprint is also supplied in designs eminently suitable for modern home decor.

Lampshades made from Rilfoil. Many colour effects and embossed designs are available to manufacturers of lampshades, fancy goods, etc. Especially suitable for vacuum forming.

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British Oxygen Chemicals make Melamine; names and addresses of manufacturers of Melamine resins and moulding powders will be supplied with pleasure. Please write for further information to:—

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Tel: Birtley 145
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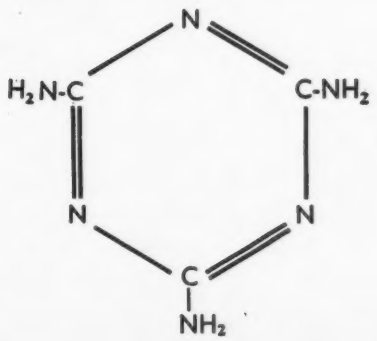
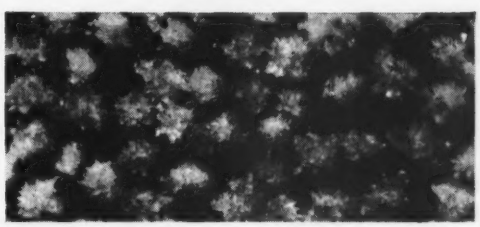
Melamine





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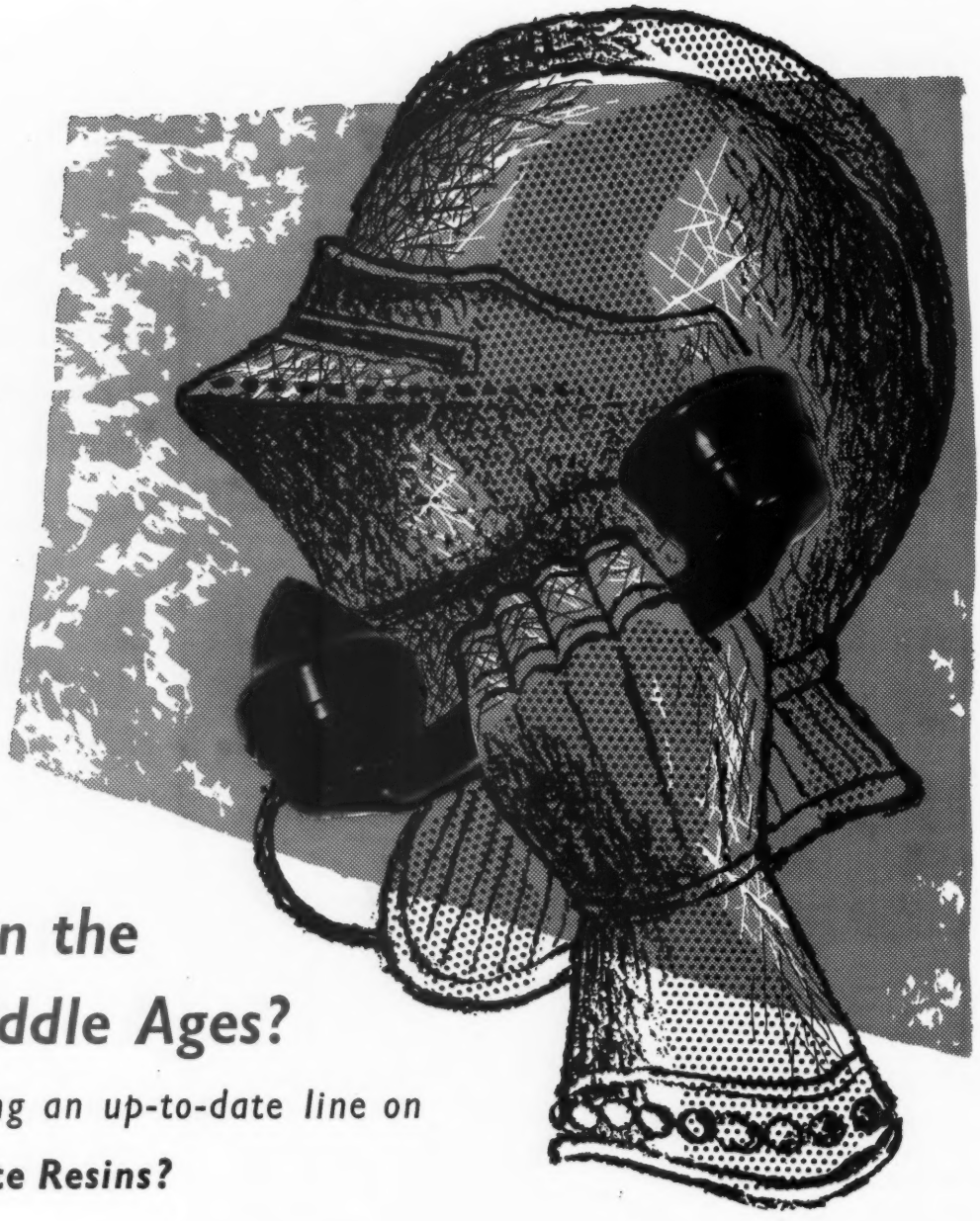

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Go-ahead manufacturers are now using Shell's radically superior Epikote Resins for potting techniques.

The excellent adhesion of Epikote Resins provides a good hermetic seal, which ensures outstanding resistance to humidity. Low shrinkage, toughness and good all-round electrical properties make them particularly suitable for potting and casting with a performance far beyond that obtained from conventional materials.

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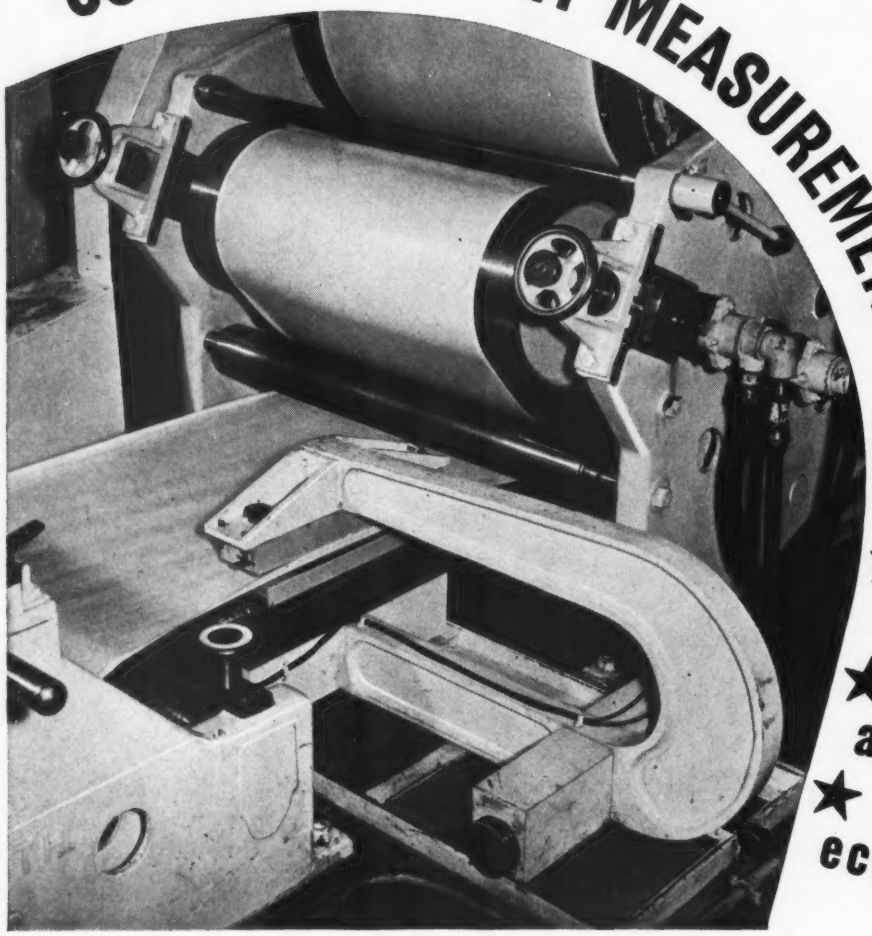

★ immediate
★ continuous
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Continuously, accurately and *immediately*, the Baldwin Atomat will measure plastic and rubber coating weight by means of the latest industrial use of nuclear energy. By the use of a differential gauge which emits β-rays, coating measurements can be carried out to closer limits, ensuring a higher standard of quality. This can result in increased output and reduced wastage and labour costs. Brochure L-124 gives full details and will gladly be sent on request.

The **BALDWIN ATOMAT**

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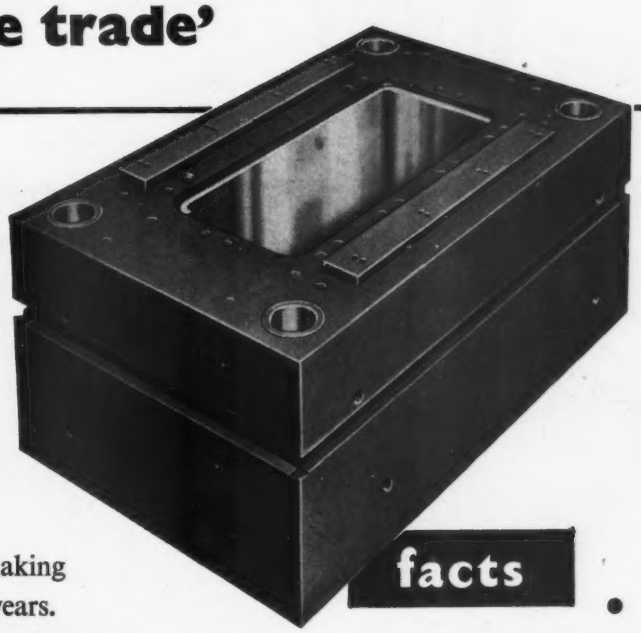
NP 39

something new

National Plastics TOOLMAKING DIVISION now makes moulds for 'the trade'



National Plastics experience, skill and reliability as mould makers is now available for the first time to moulder firms looking for toolmaking capacity.

Quite a few old timers at our Walthamstow factory have been making moulds for plastics for thirty five years. Building on a nucleus of this calibre our tool division has now so expanded its plant and skilled personnel that it can make moulds for the trade. This in addition to its normal toolmaking work for National Plastics customers, which is in no way affected.

facts

.. we made the mould, weighing twelve tons, for the only plastics television CONSOLE cabinet outside U.S.A.

our equipment includes FIVE Keller automatic copying machines.

we have made more radio cabinet moulds than any other tool making shop in Great Britain.

we have to our credit many highly ingenious automatic 'injection' moulds for moulding thermo-plastics.

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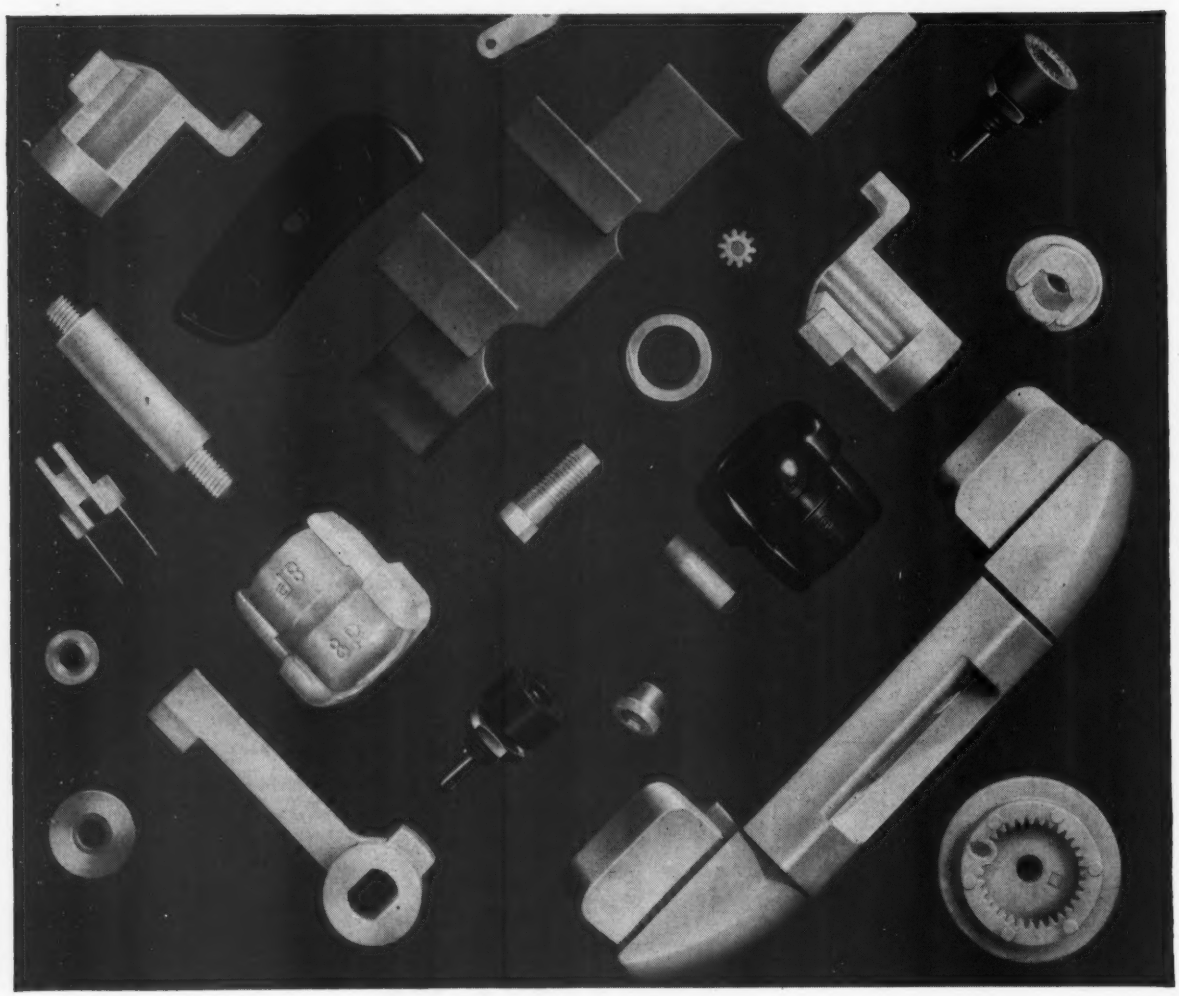
Maybe NYLON is the material for *your* particular problem. Tough, resistant to high temperatures and most chemical solvents, NYLON is eminently suitable for the moulding of a very wide range of articles.

We shall be glad to have your enquiries regarding NYLON moulding for *your* industry. Everything under one roof — Design Unit, Drawing Office, Tool Room and large Moulding Shop — completely at your disposal.



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IH48

MR. H. A. R. D. CHROME

this was a scoring problem?

Toolchrome solved it

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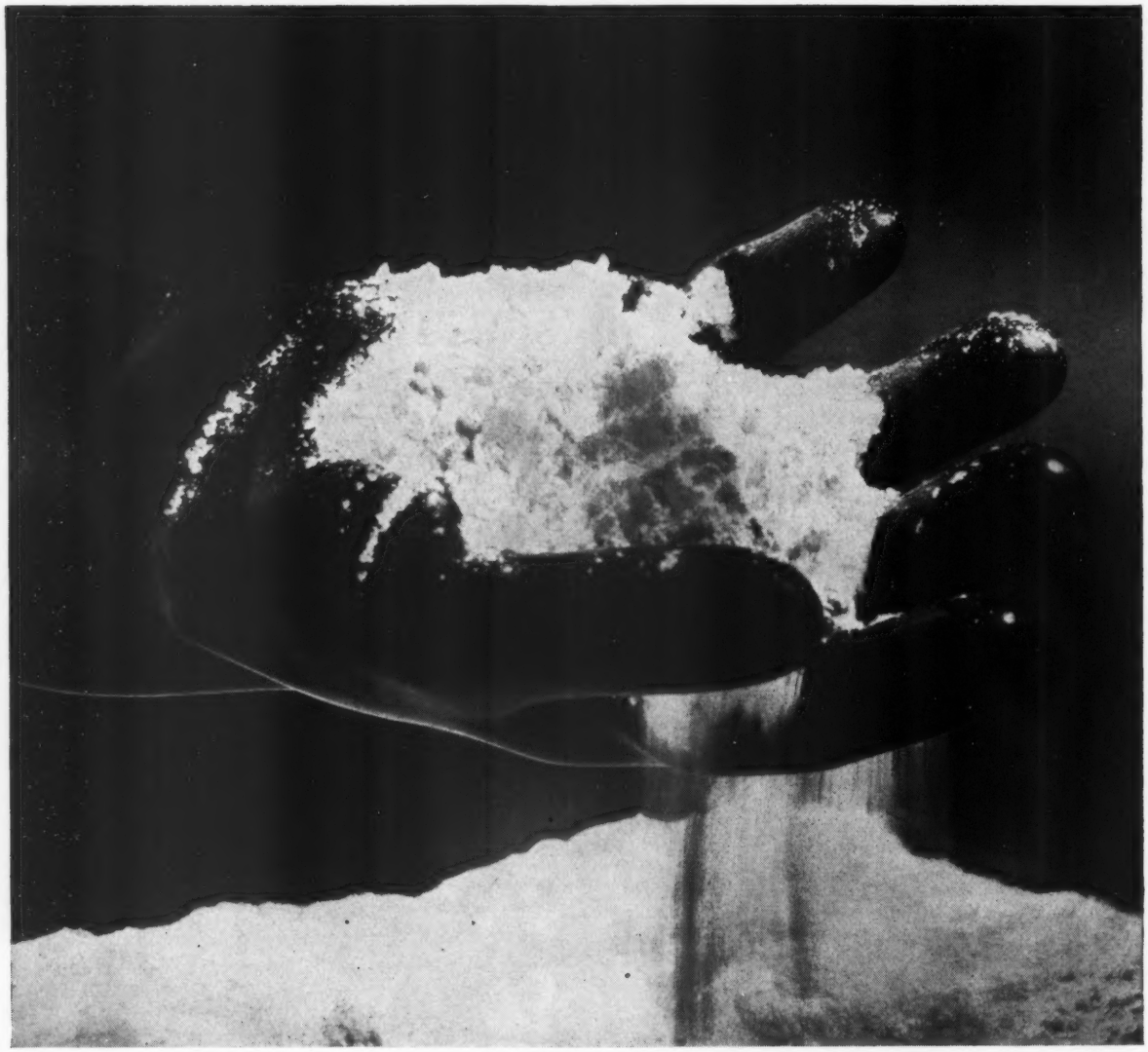

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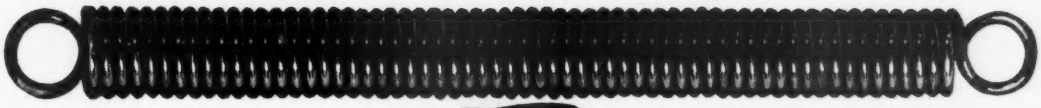
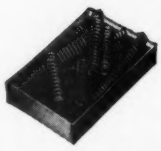
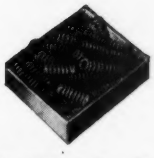
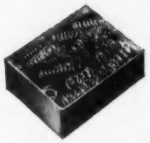




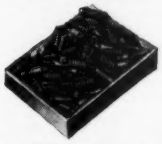
No. 760. 3 doz. Assorted Light Compression Springs 1″ to 4″ long, 22 to 18 S.W.G., ¼″ to ½″ diam. 6/6 each.



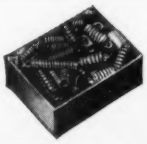
No. 98A. 3 doz. Assorted 1″ to 4″ long, ¼″ to ¾″ diam., 19G to 15G. 5/6 each.



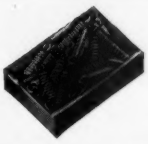
No. 757. Extra Light Compression, 1 gross assorted, ⅛″ to ⅜″, ¼″ to 2″ long, 27 to 20 S.W.G. 15/- each.



No. 388. ¼ gross Assorted Small Expansion Springs. ⅜″ to 1¼″, 18G to 21G. 9/6 each.



No. 758. Fine Expansion Springs. 1 gross Assorted ⅛″ to ⅜″, ¼″ to 2″ long, 27 to 20 S.W.G. 15/- each.



No. 466. ¼ gross Assorted Small Expansion Springs ⅜″ to 1¼″ long, 3/32″ to 3/16″ diam., 21G to 24G. 6/6 each.

No. 1013. 1 gross Small Coil Compression Springs, ⅜″ to 1¼″ long, 3/32″ to $\frac{7}{16}$″ diam., 24G to 19G. 6/- each.

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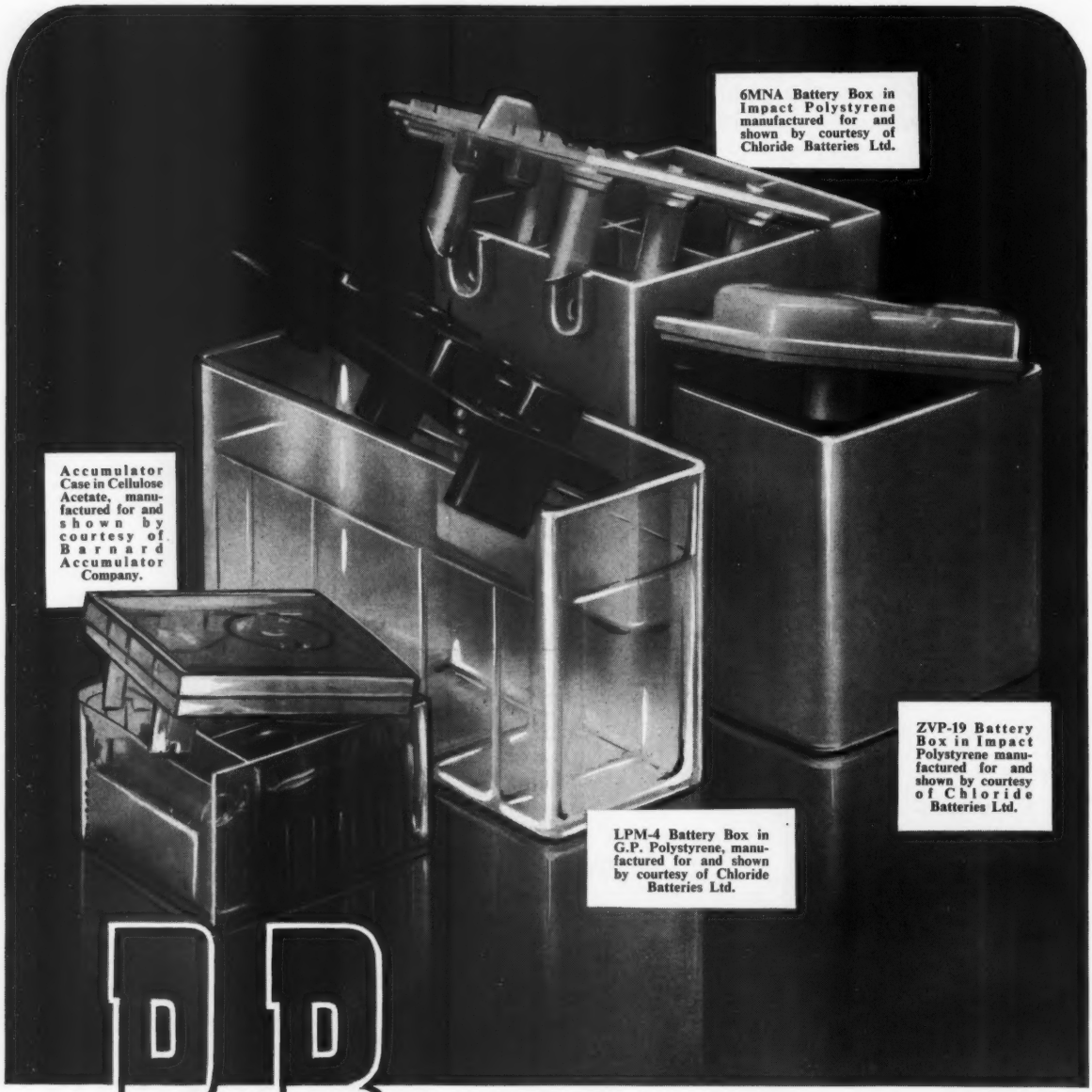
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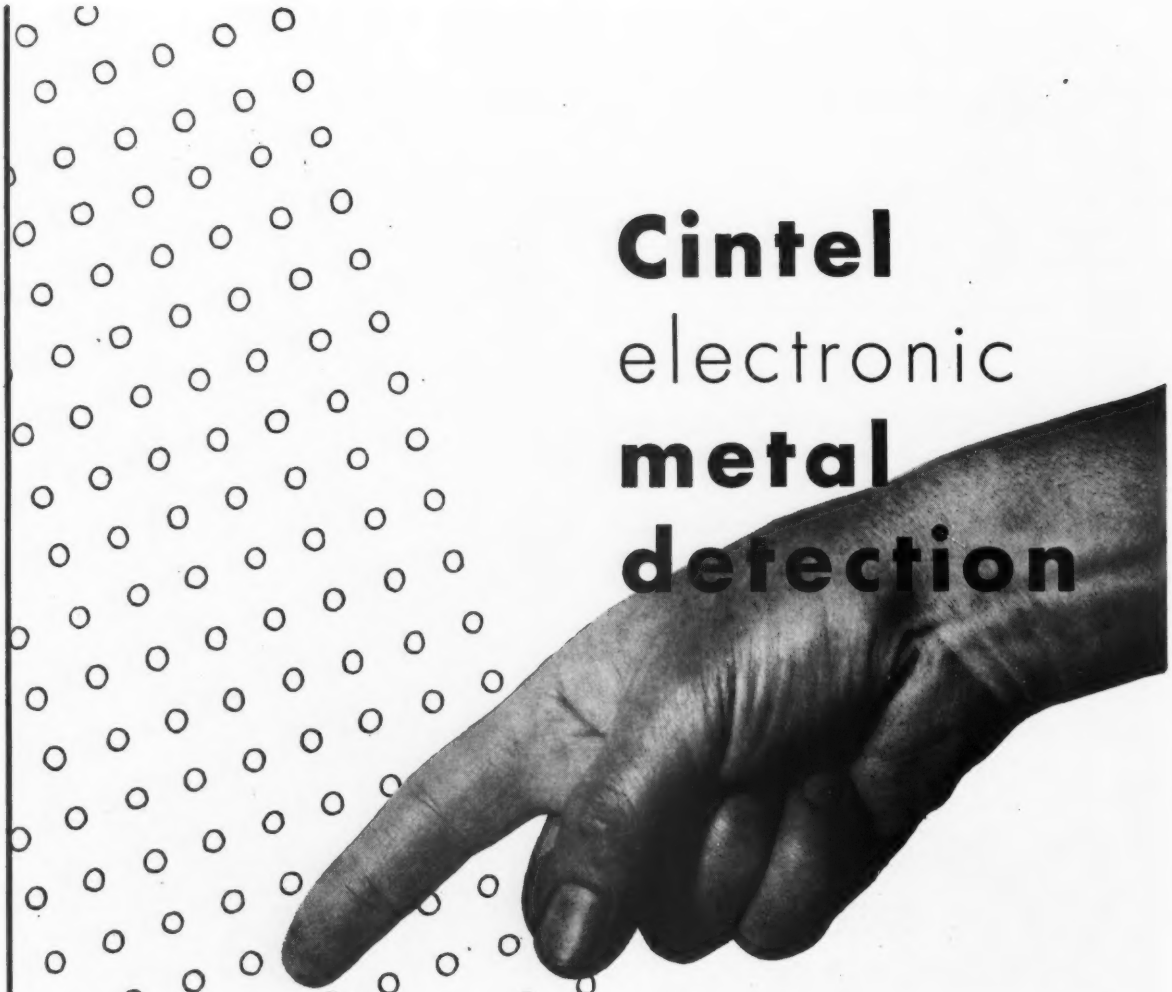

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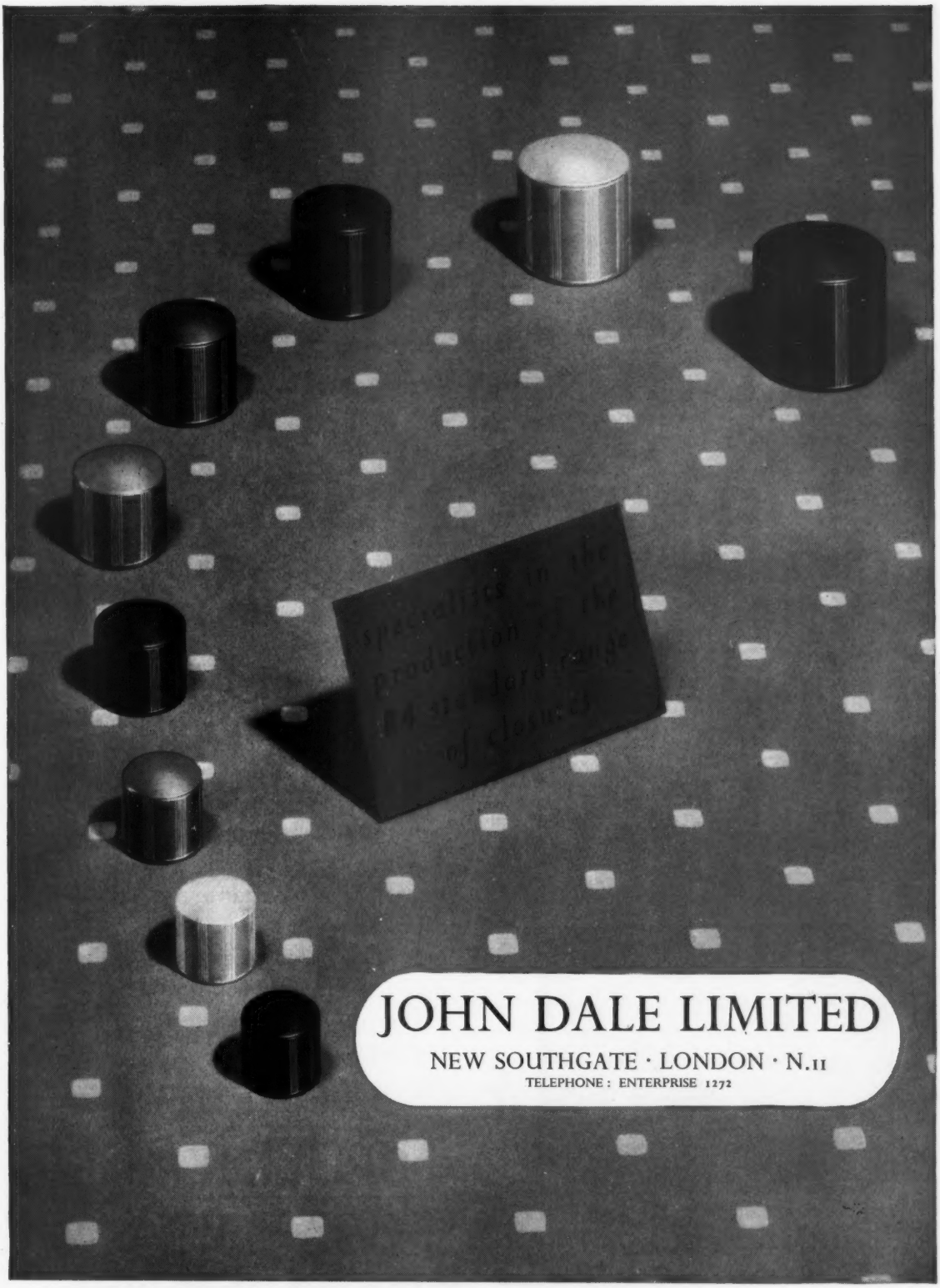
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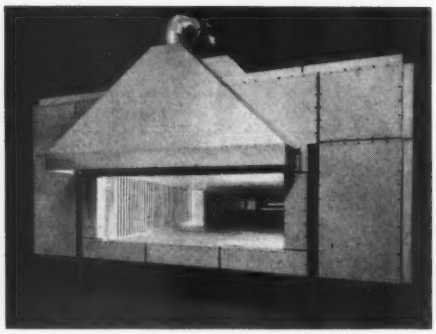

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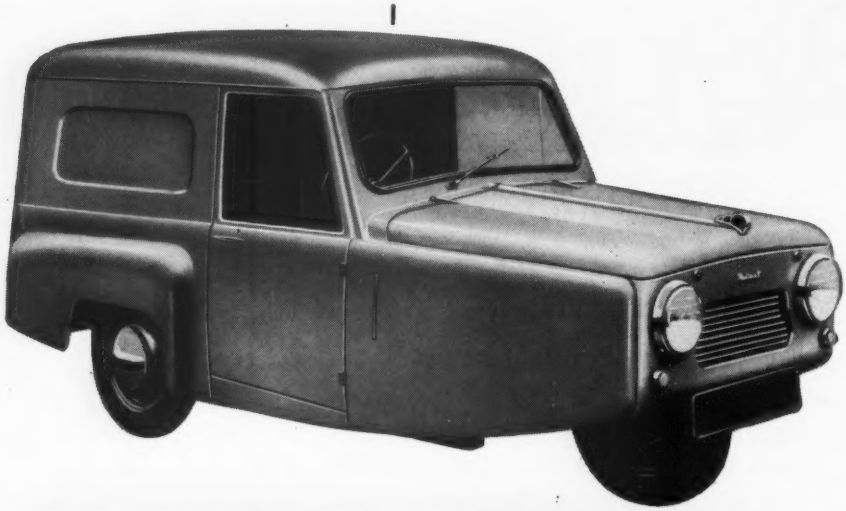

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colour in the hands of the artist

2 OIL

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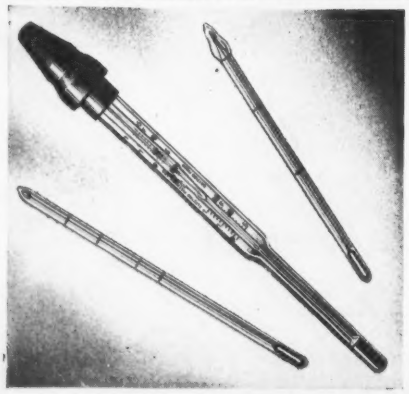

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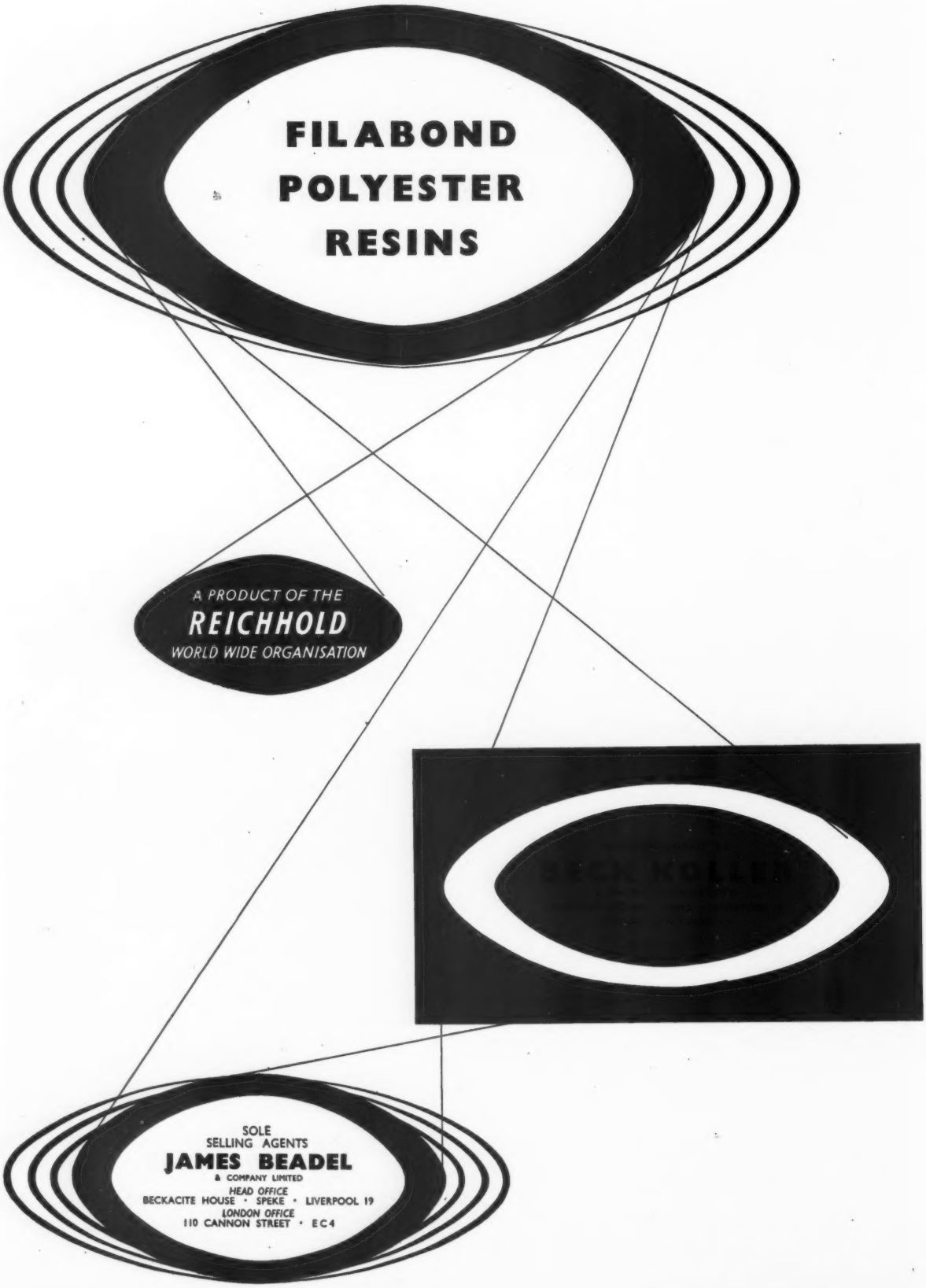
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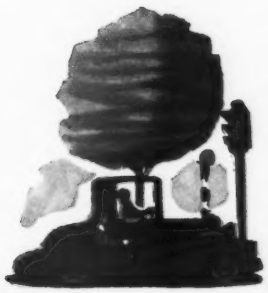

A driver of no mean repute
When hailed at the lights by a toot
Queried the tooter
Who'd tooted his hooter
To bring to the attention of the party
of the first part the fact
that PVC makes an effective, economical
and easy-to-fit petrol tubing.

More limericks—

A beautiful star of the screen
While bathing as part of a scene
Remarked with a squeak
My dear, how unique!
Look at that darling PVC sealing strip
between the bath and the wall—
how utterly effective, economical,
attractive and easy to fit.

from the lively

As the water shot out in a shower
Drenching all but the fire
with its power
An irate passer-by
While wiping his eye
Observed that he would strongly
recommend all manufacturers
of hose equipment to bear in mind
that PVC makes a remarkably effective,
tough, durable fire hose lining.

lads at Lorival!

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A barmaid remarked with a titter
You've had quite a few
And each pint has passed through
Our new Polythene tubing which is ever
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flavour of beer and is cheap to instal
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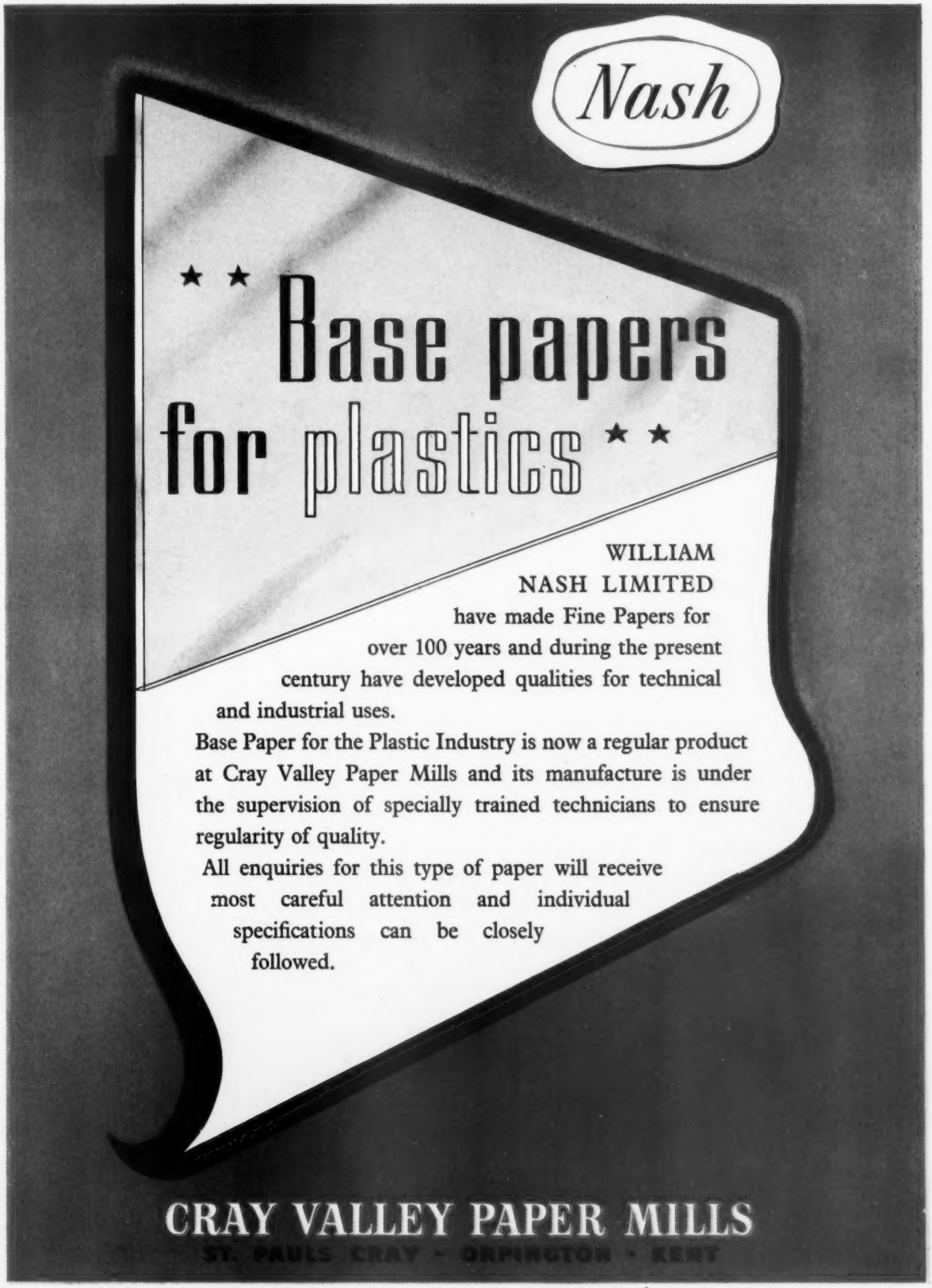
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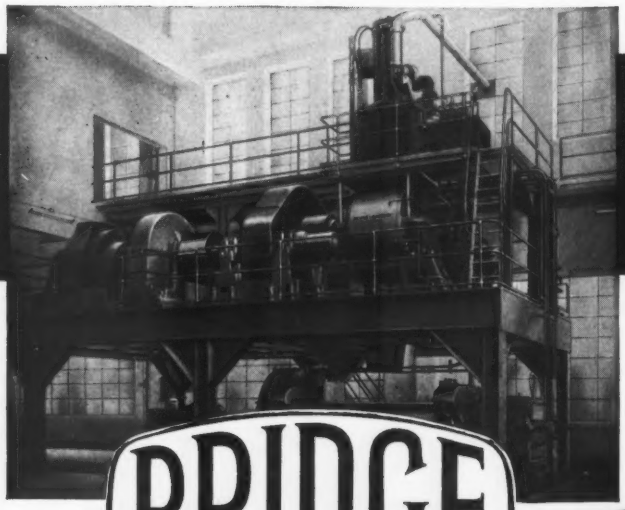

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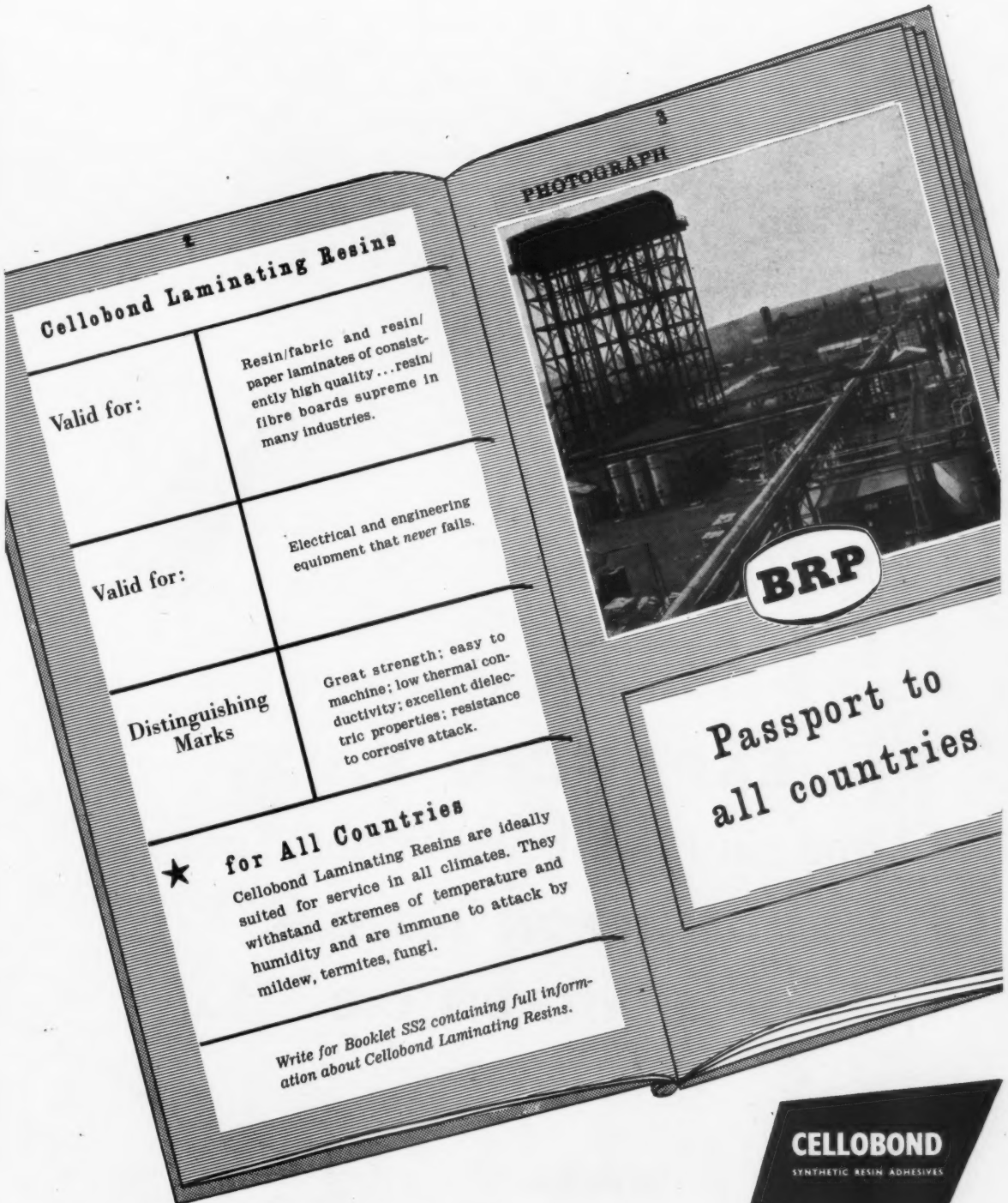
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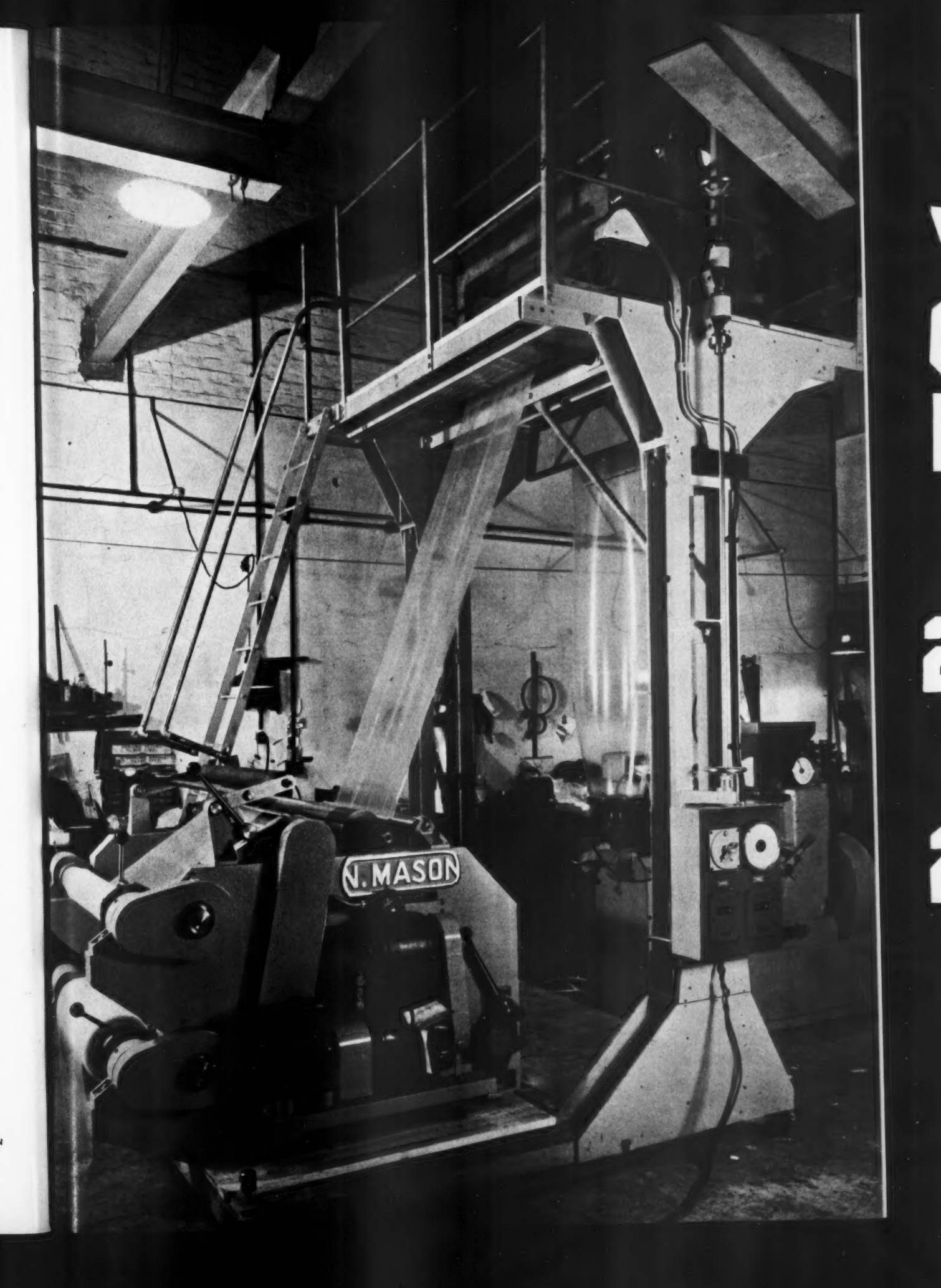
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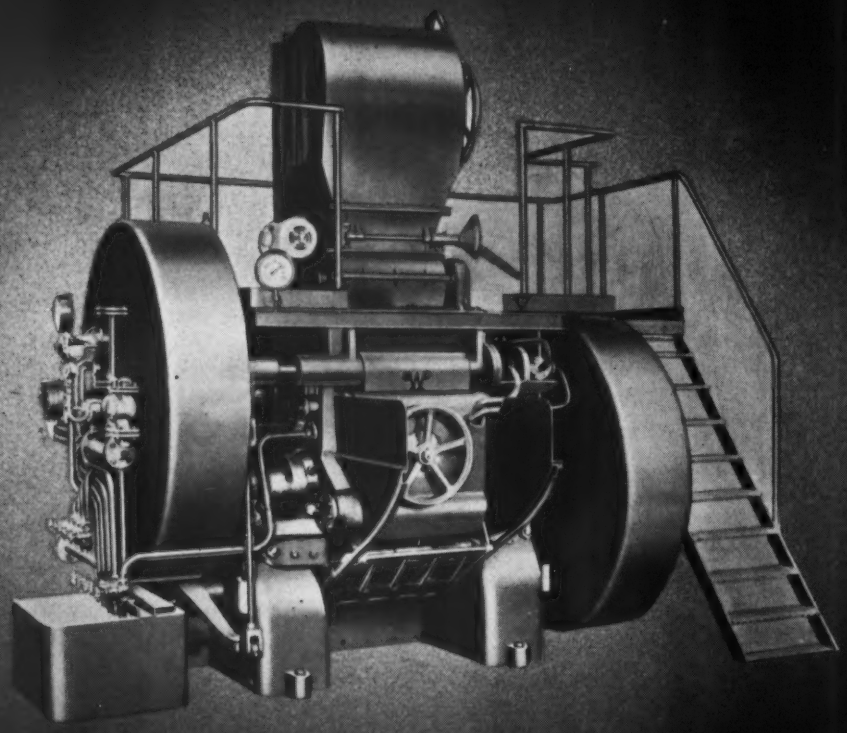

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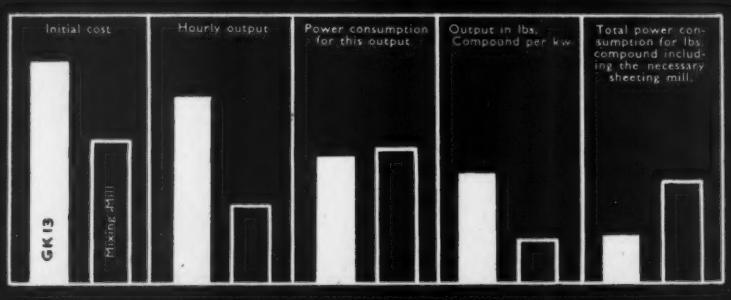
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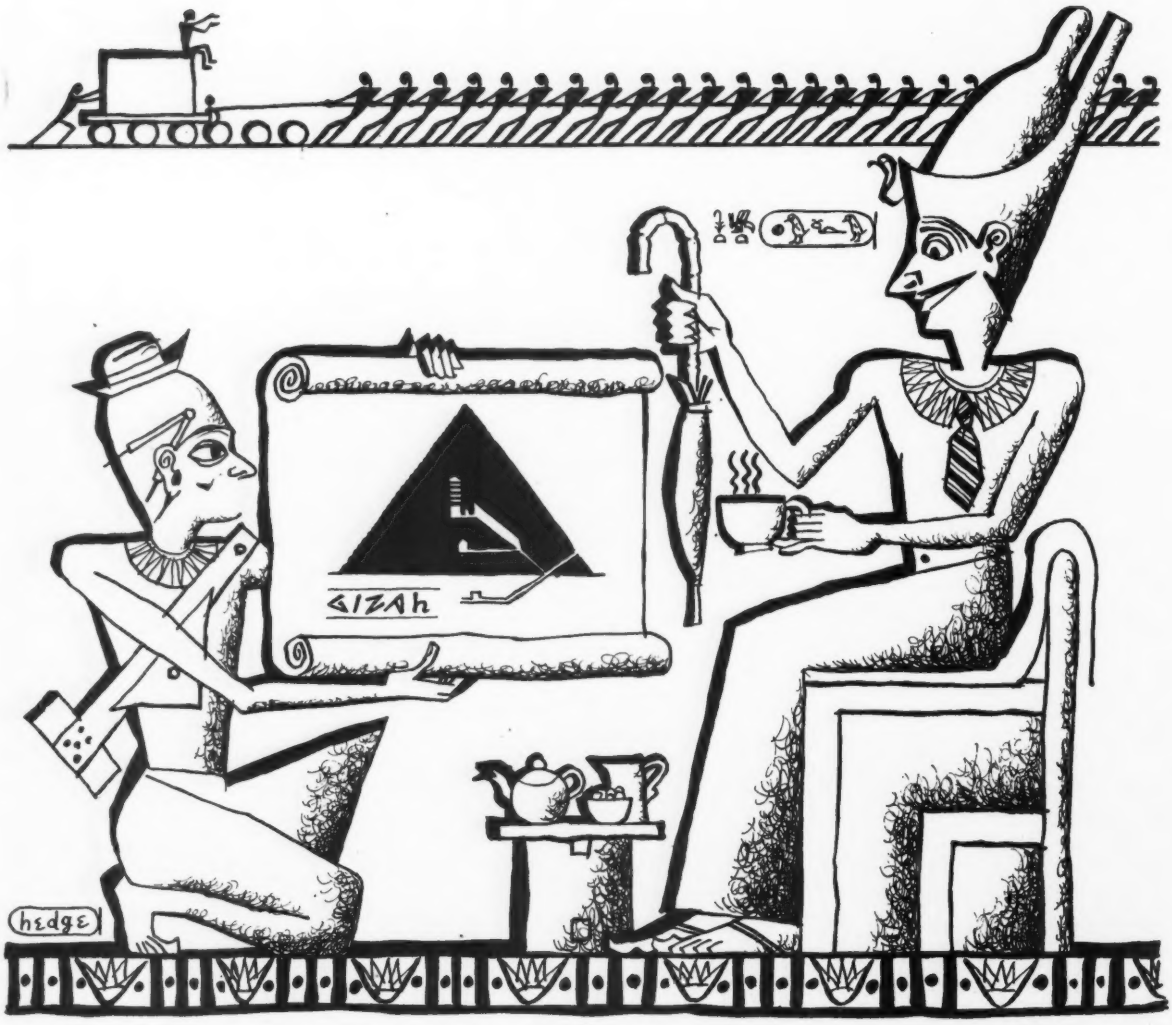

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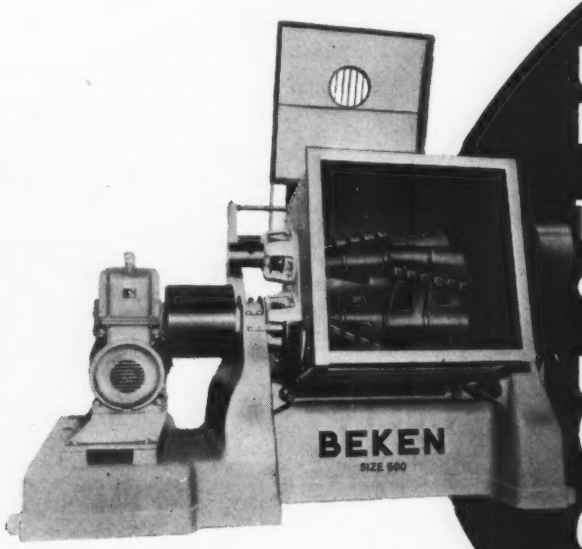

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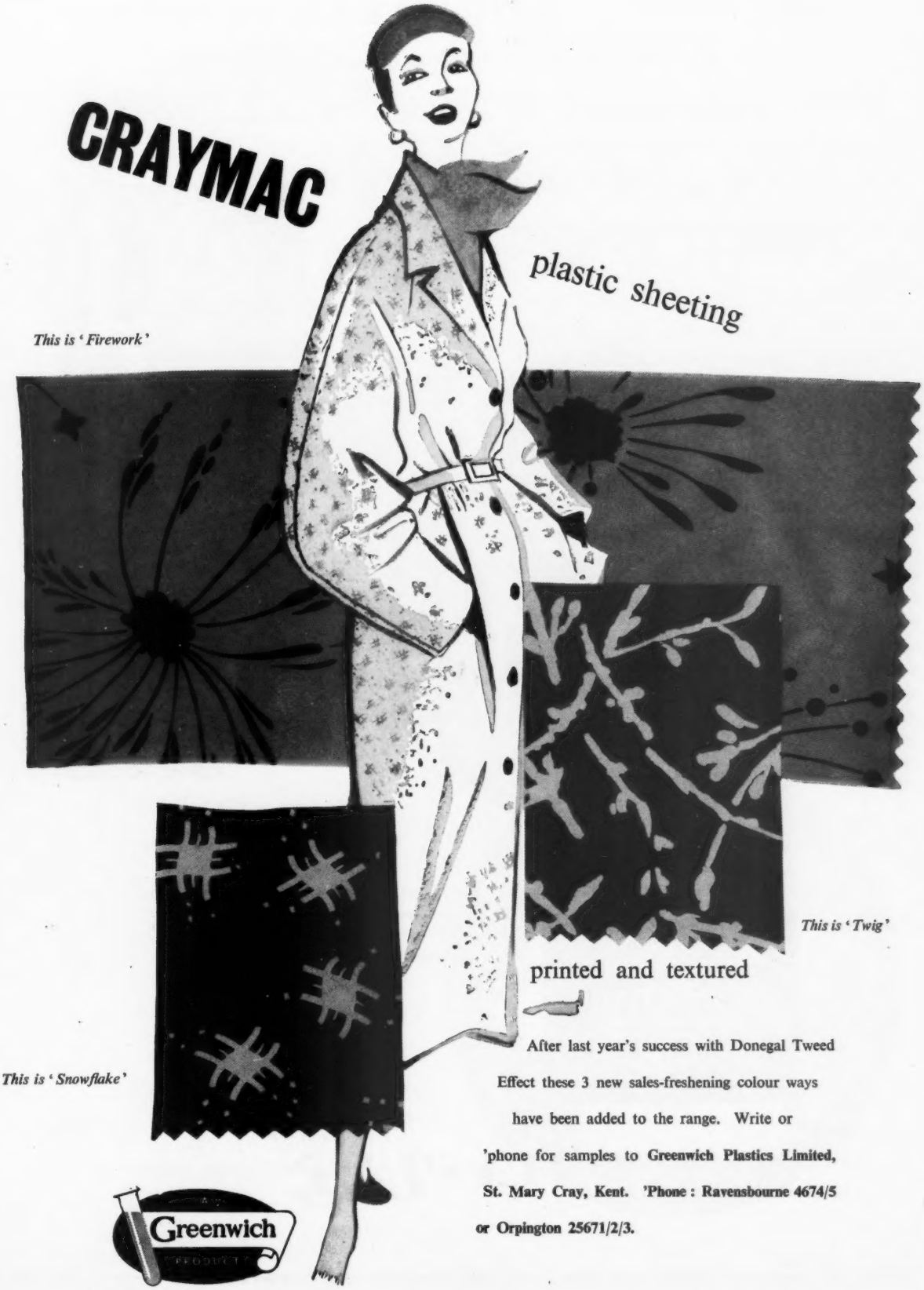

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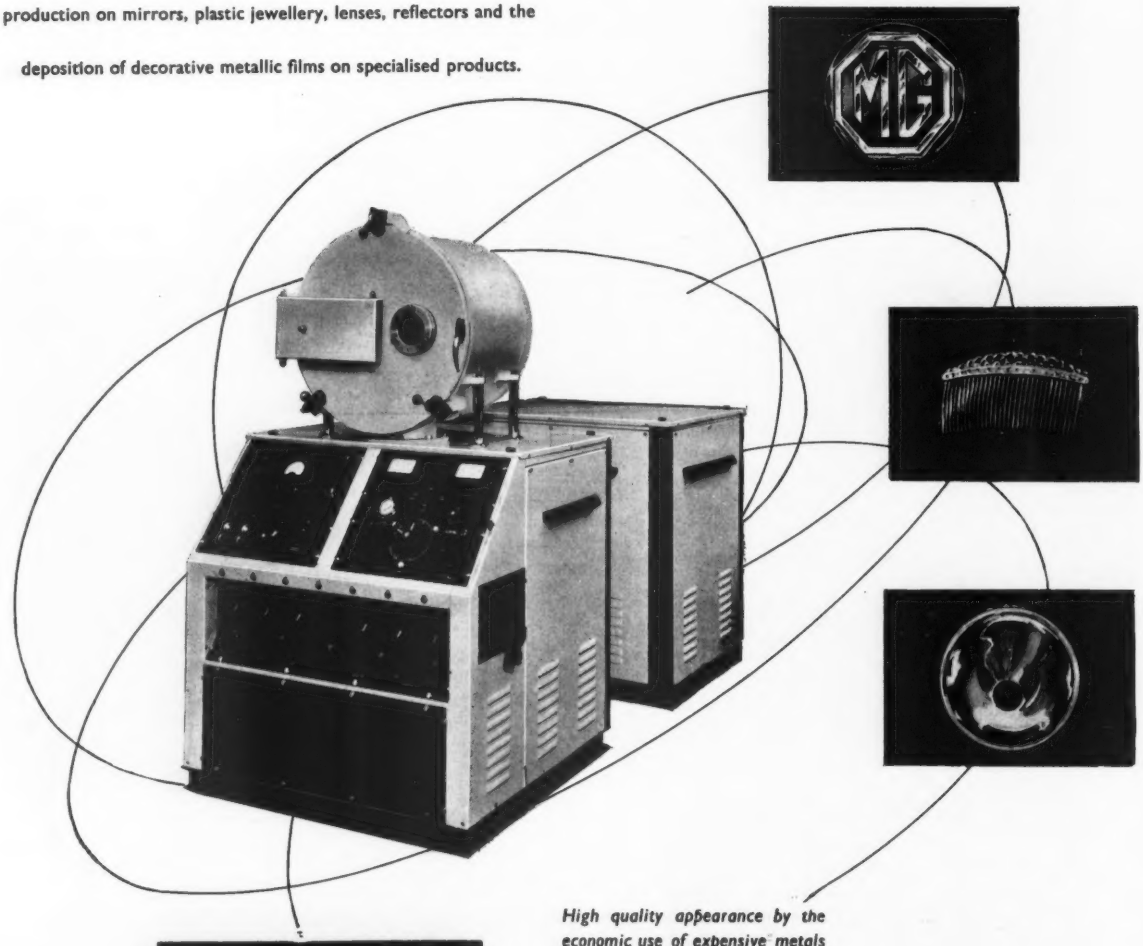

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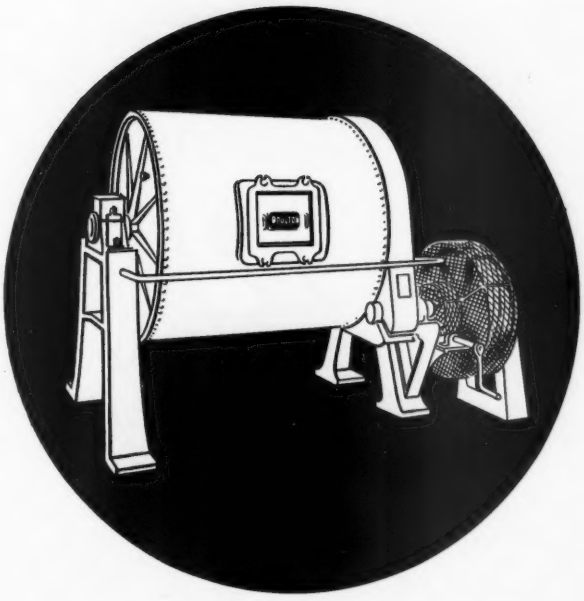

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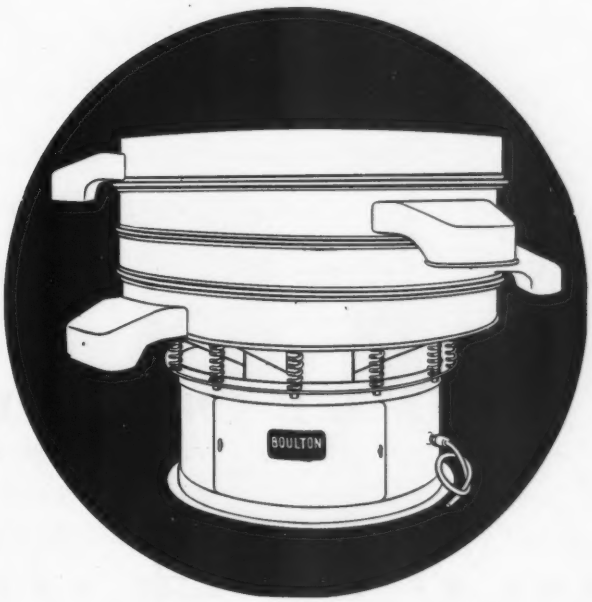

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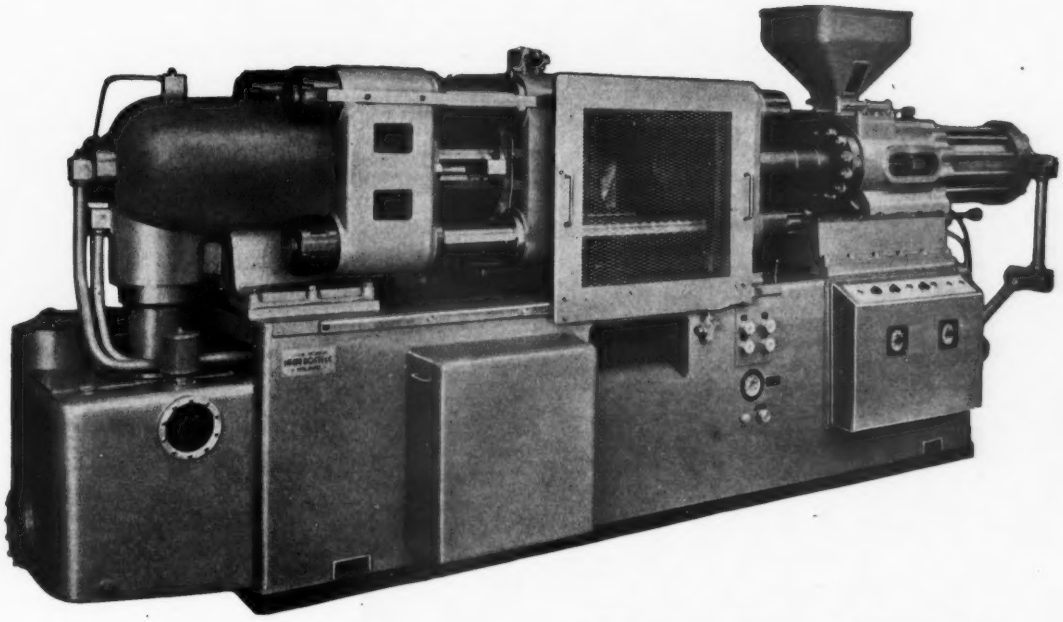

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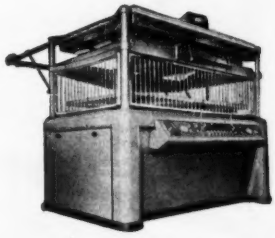

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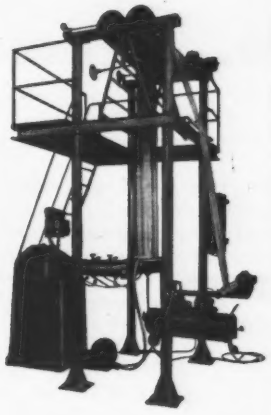

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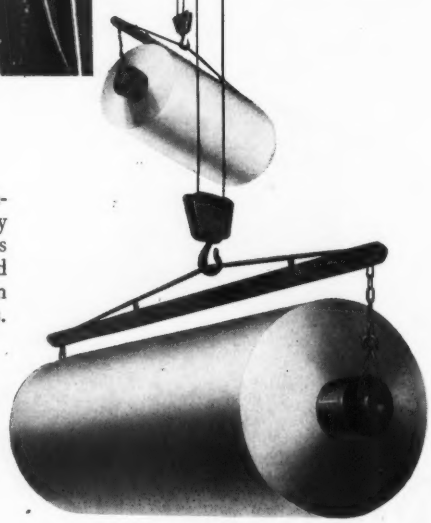

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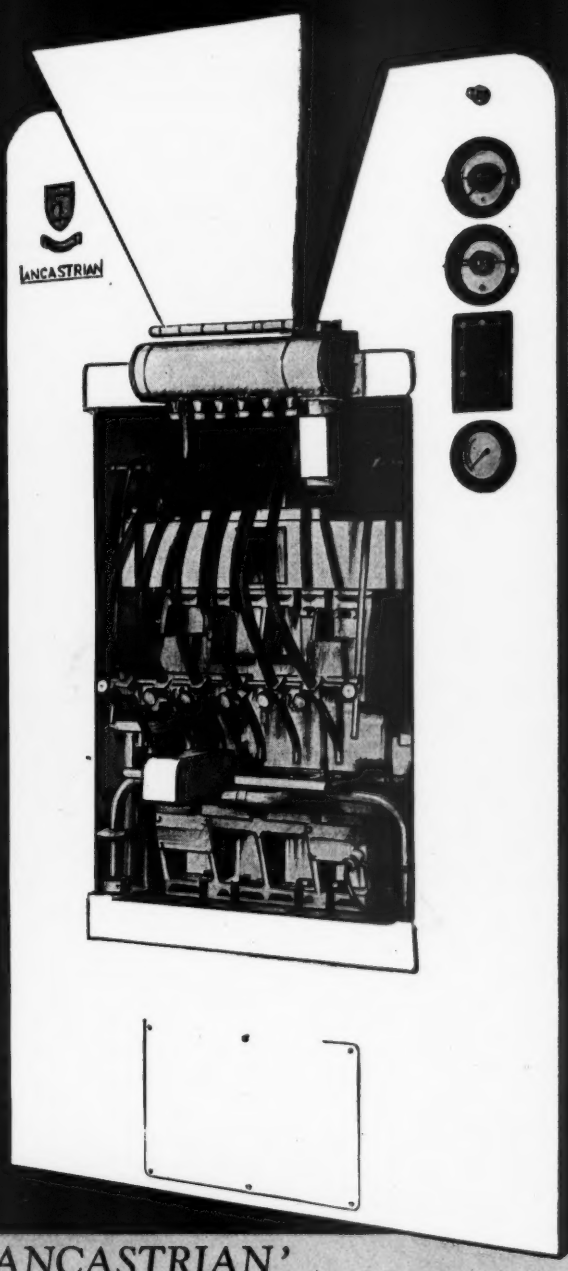

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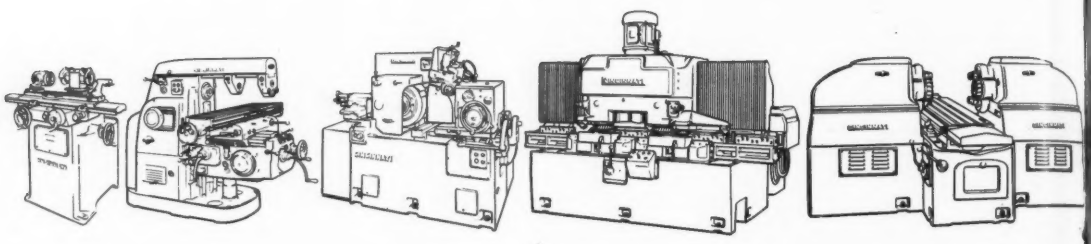

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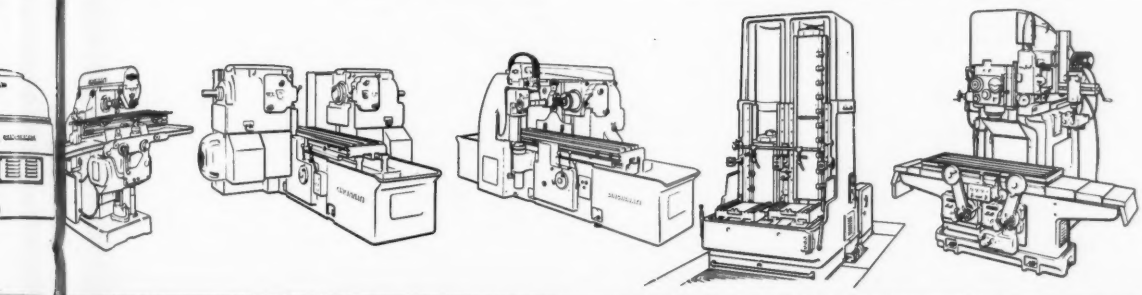

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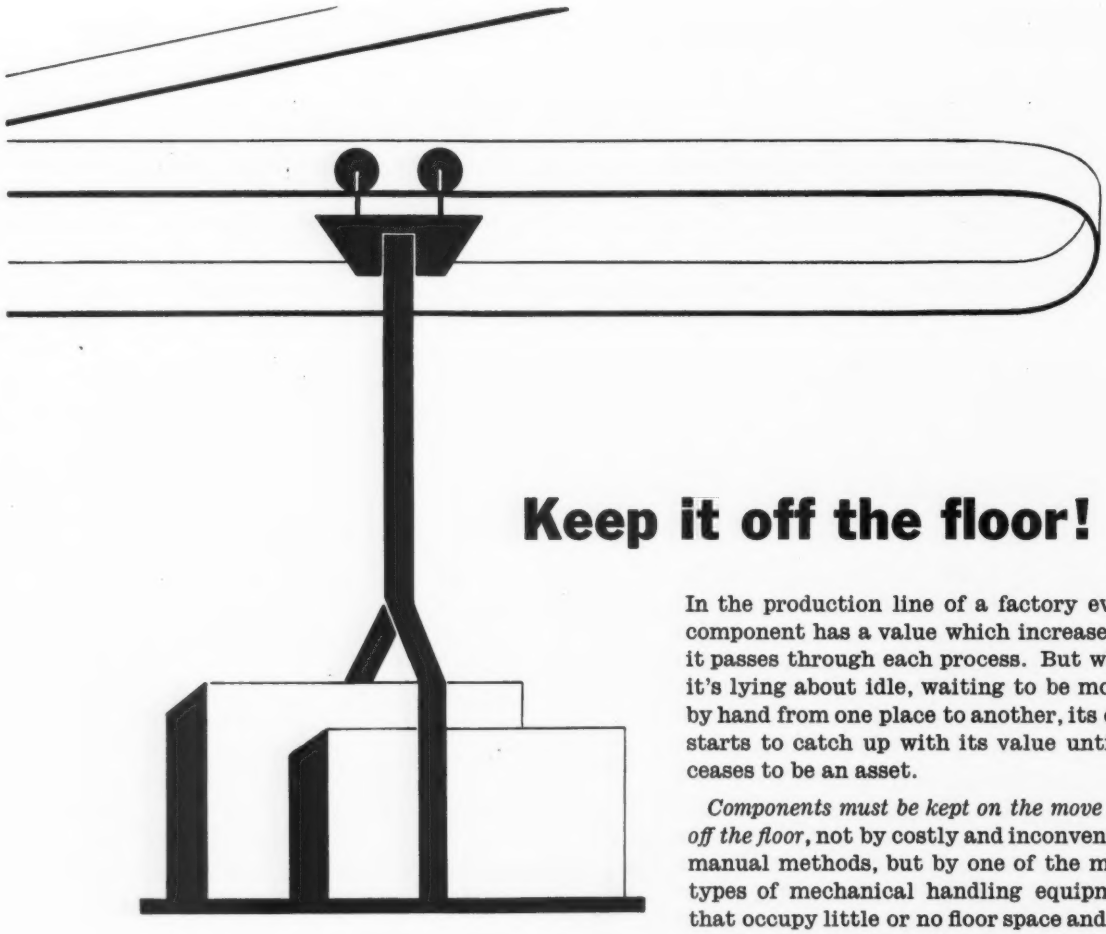

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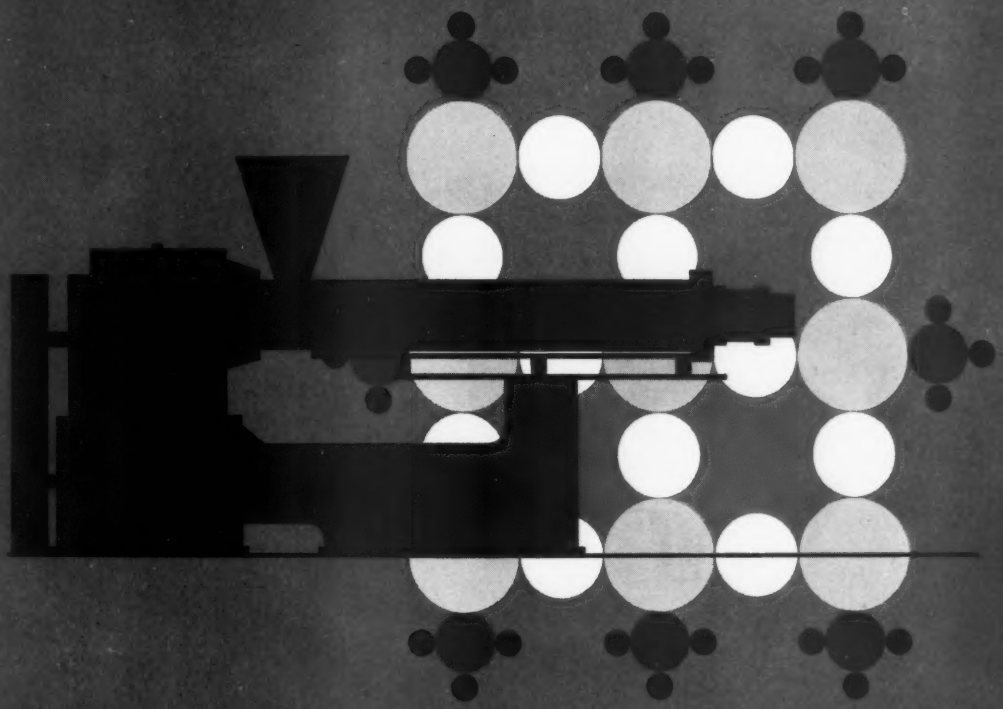

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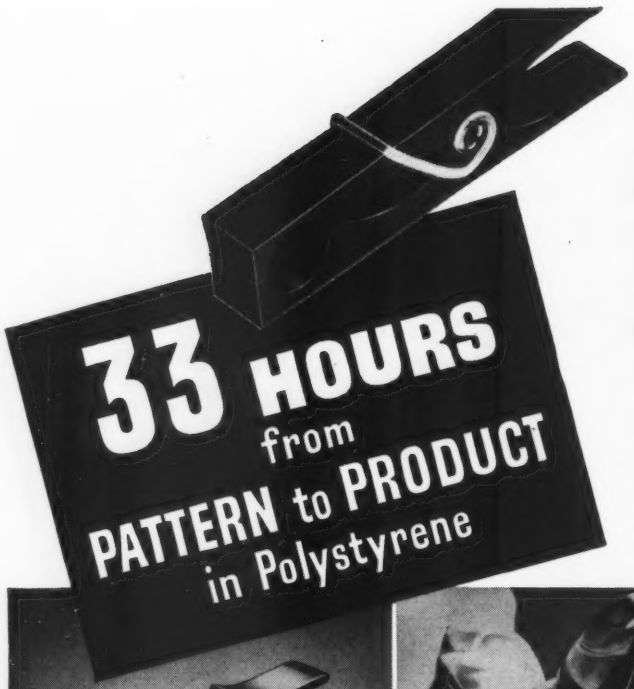
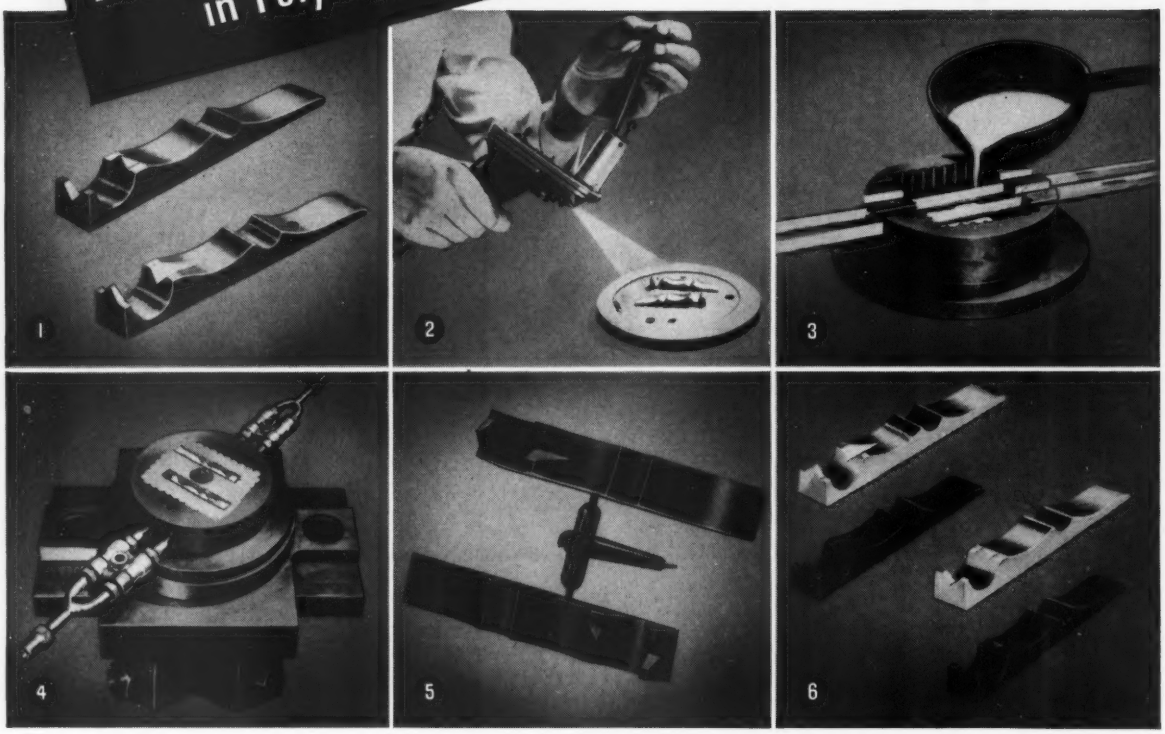


For the First Time!

By courtesy of Messrs. S. Smith & Sons (England) Limited, we illustrate manufacture of injection mould for production in Polystyrene in a total time of 33 hours and a fraction of cost of machining.



1. Aluminium master pattern.
2. Spraying pattern with Cerrocast.
3. Pouring molten Cerrocast to back sprayed shell and embed water cooling tubes.
4. Complete mould. 5. Typical shot.
6. Comparison of patterns and mouldings.

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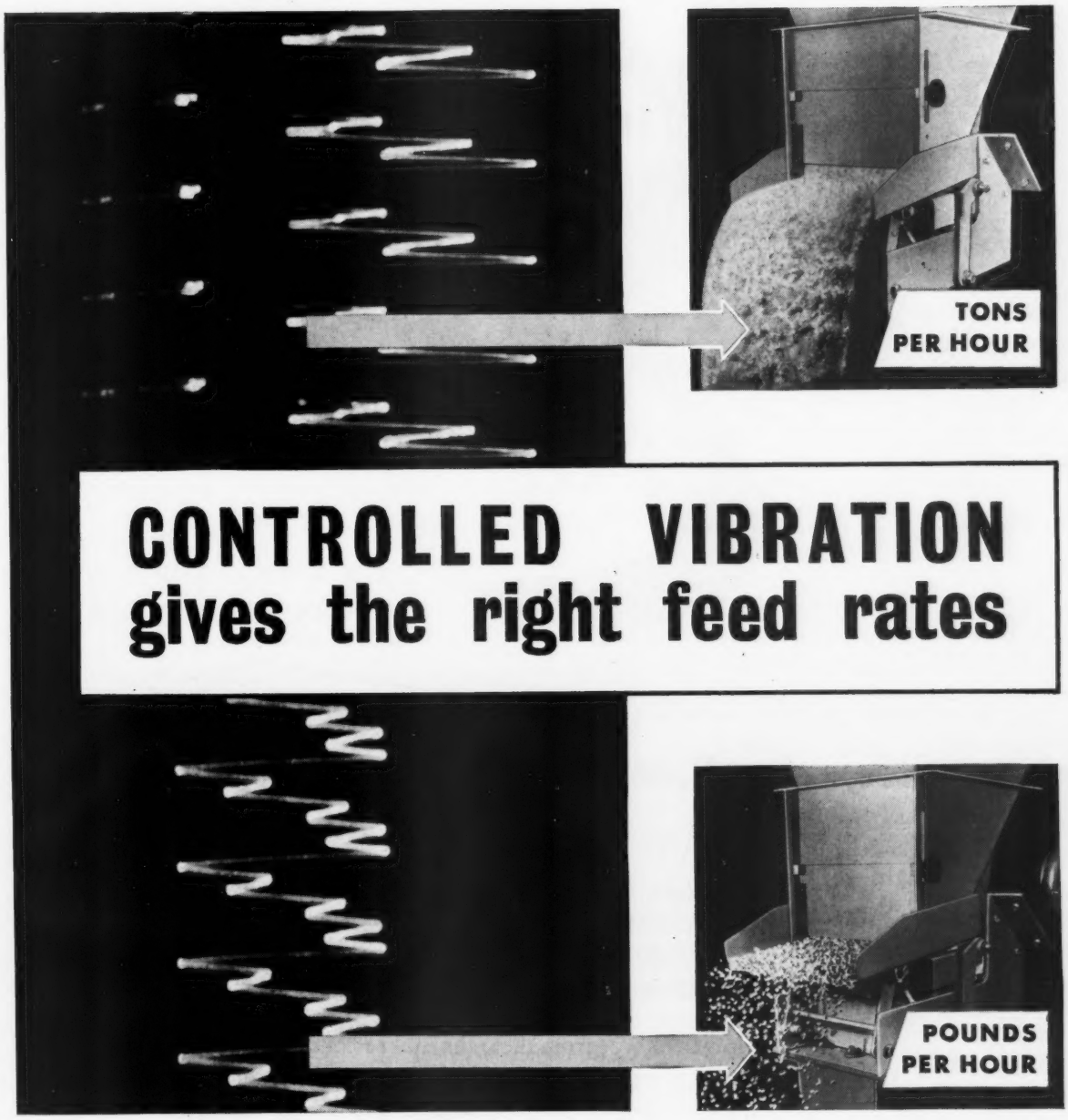

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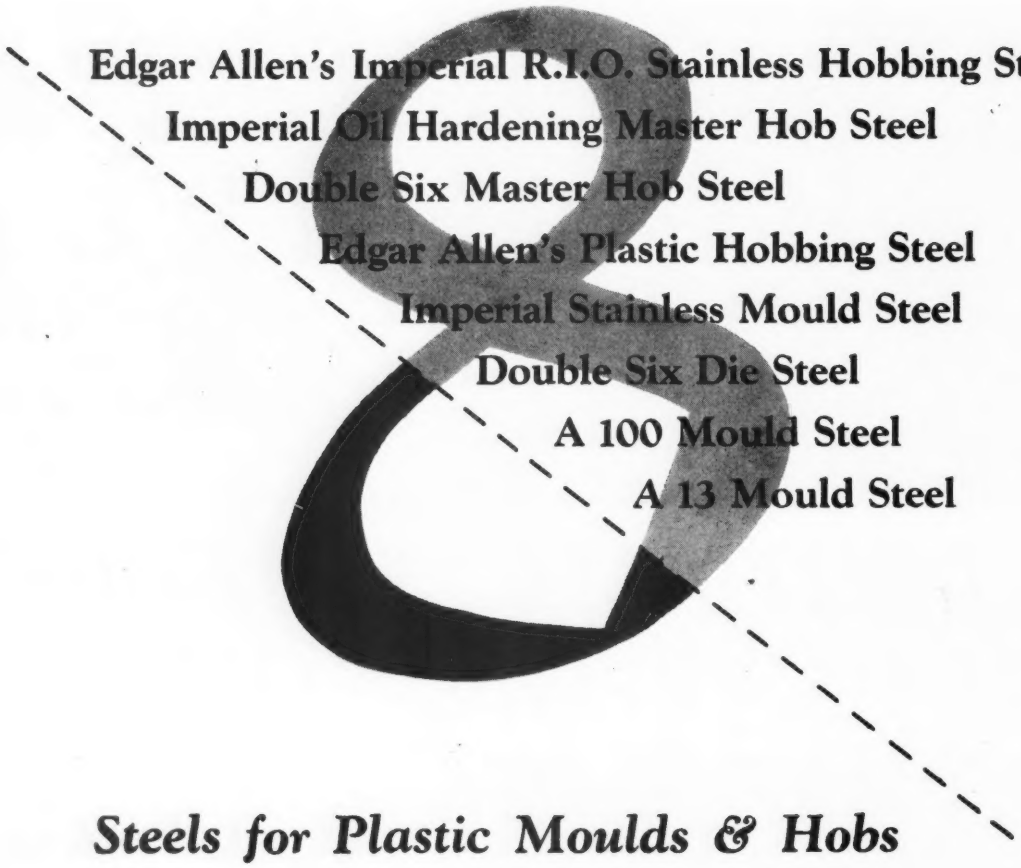
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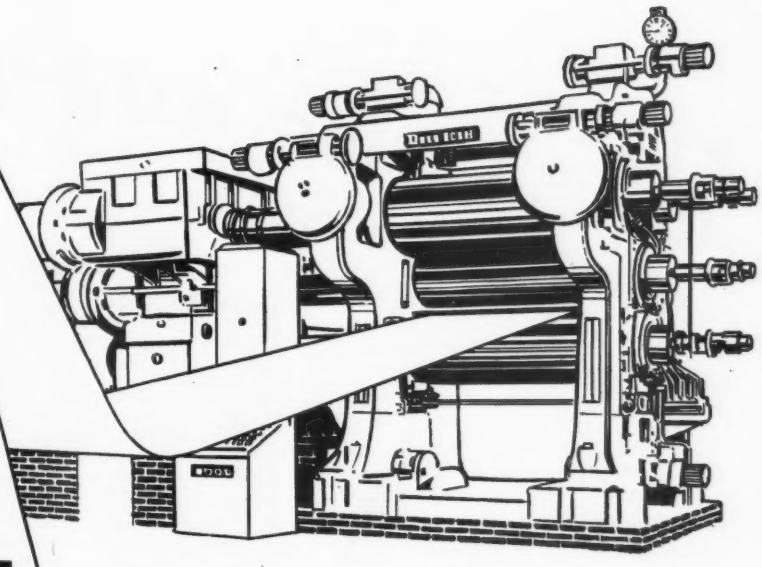

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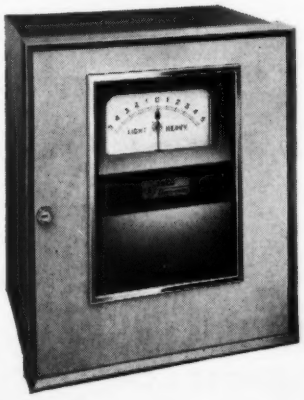

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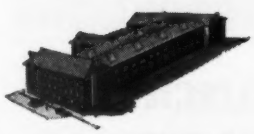

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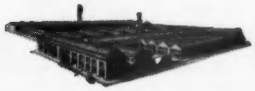

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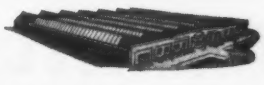

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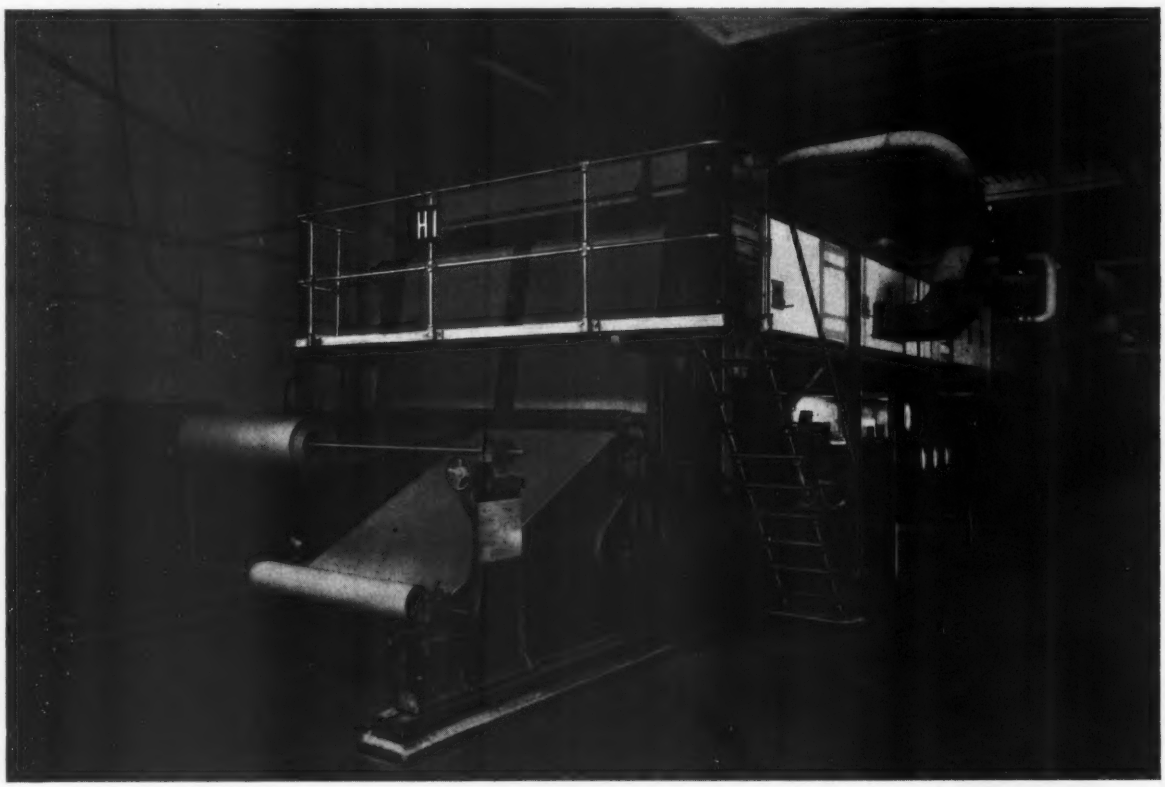

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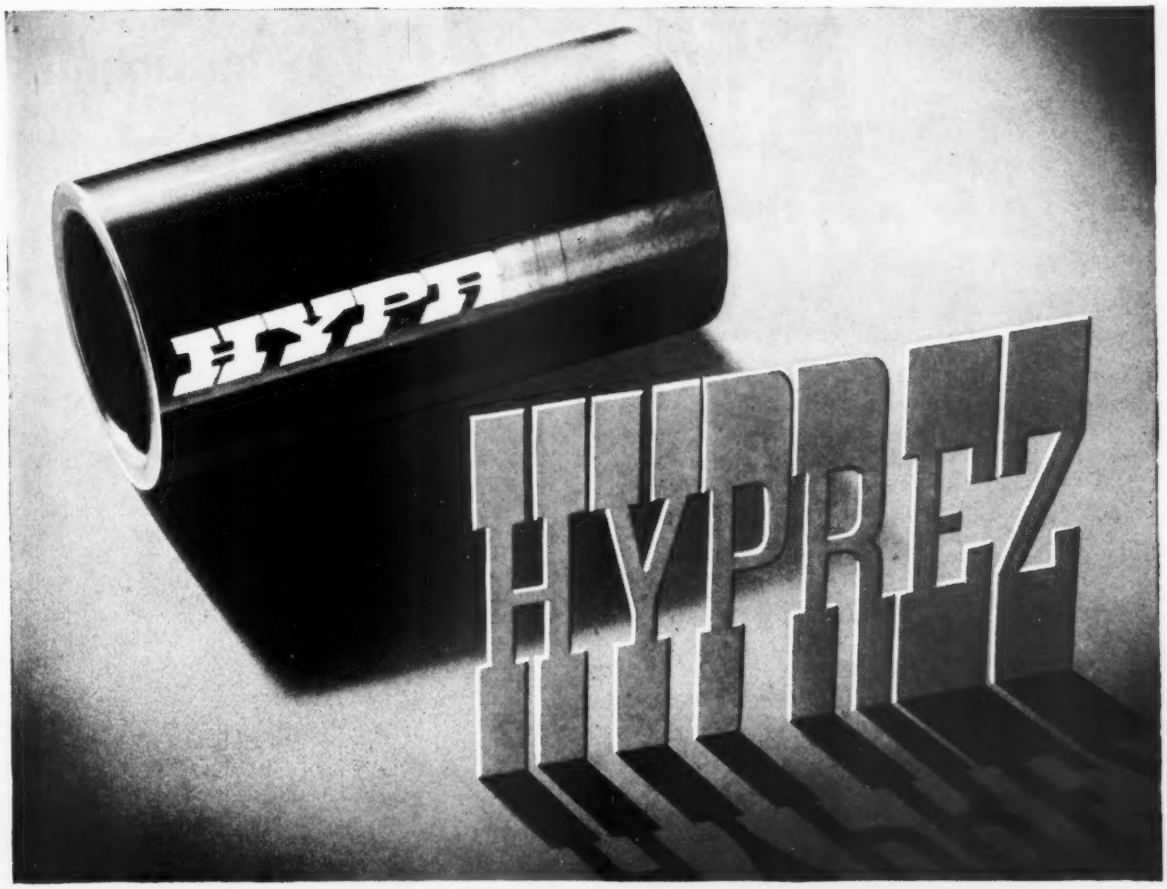
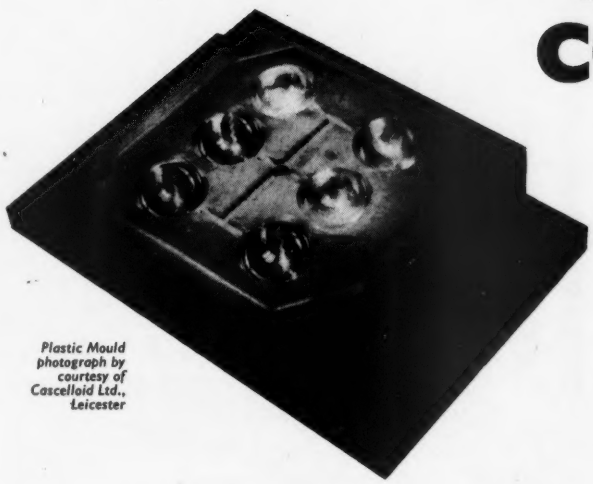


DIAMOND COMPOUND



Plastic Mould photograph by courtesy of Cascelloid Ltd., Leicester

imparts to plastic moulds a finish which is reflected in the product.

The illustration (left) shows a plastic mould part-finished with Hyprez, part-finished to a normal degree.

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B ½ oz. rectangular G.P. Phenolic pellet 2⅛" long made 3 at a time. 57 per minute.

C ½ oz. bottle stopper preform 1½" dia. made from G.P. Phenolic. 18 per minute.

D 1 oz. twin-made G.P. Phenolic pellet 1⅛" radius. 36 per minute.

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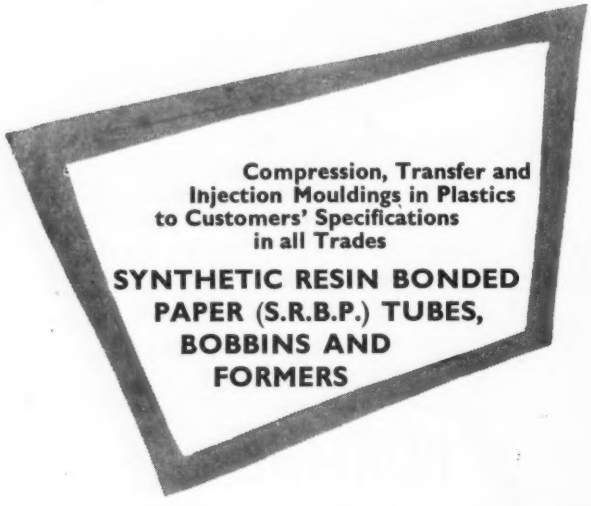

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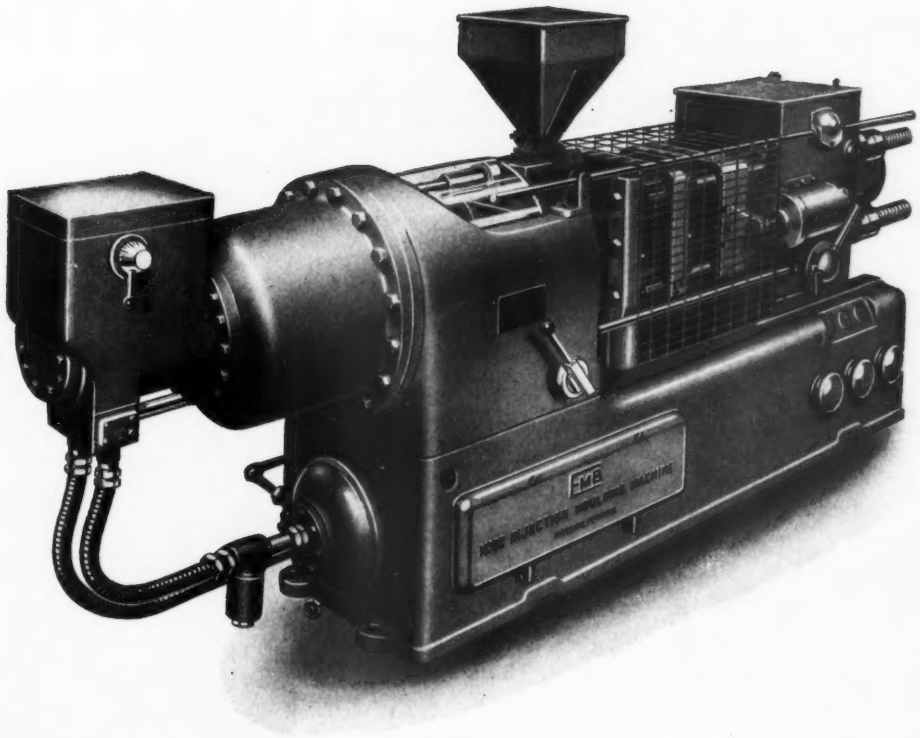

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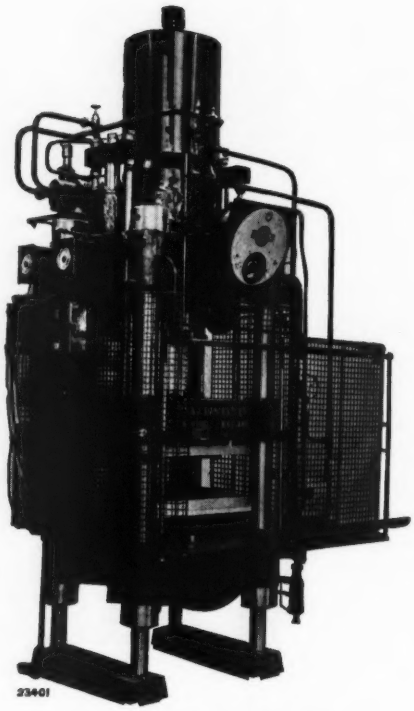
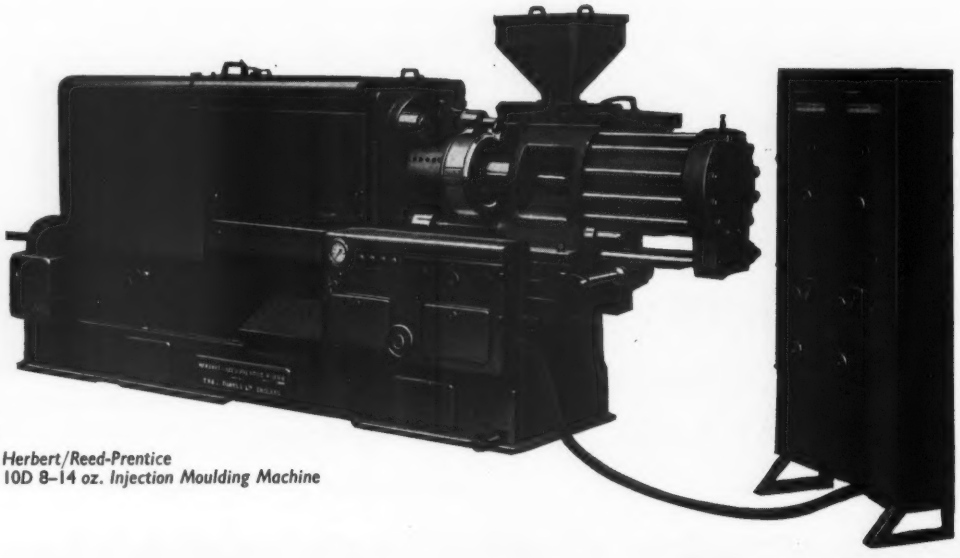


Daniels 150 ton Down-stroke Press



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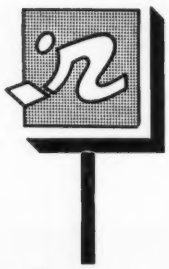

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A handle to its name!

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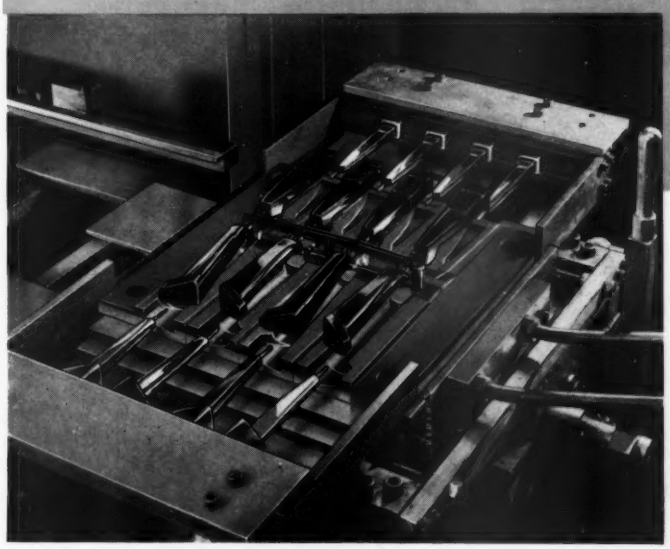
The two handles for the latest pressure cooker consist of an upper and a lower moulding, carefully designed to meet together. Both mouldings are hollowed out, entailing long and slender core pins which dictate the use of a transfer type mould.



THE TOOL AND PRESS

The tool is designed to produce four upper and four lower handles at a time on a BIPEL Type 200 Auto Control Press. The die plate is withdrawn into an auxiliary fixture, where all the side cores are withdrawn at the same time and where, with pneumatic assistance, all the eight mouldings are ejected from their dies.

THE MATERIAL AND PELLETS

The handles are moulded from Phenolic material, the total weight needed for eight mouldings being 22 ounces. This large charge is loaded as six pellets, made in a BIPEL Pelleter, and preheated to speed up production.

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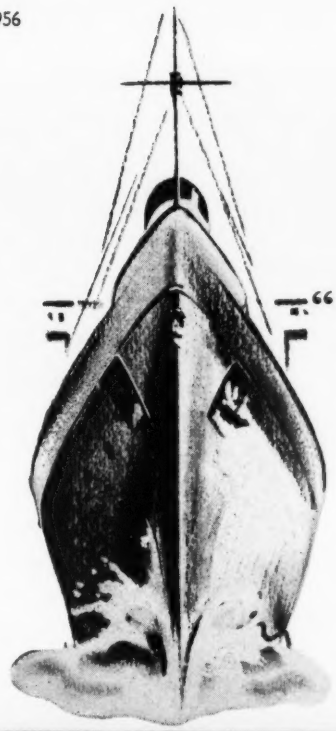

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- *Loudspeaker grille moulded by Kent Mouldings for Kolster-Brandes Ltd., Sidcup, Kent.*
- *Assembling the K-B. MR10 set—the grille being positioned at the Sidcup factory.*

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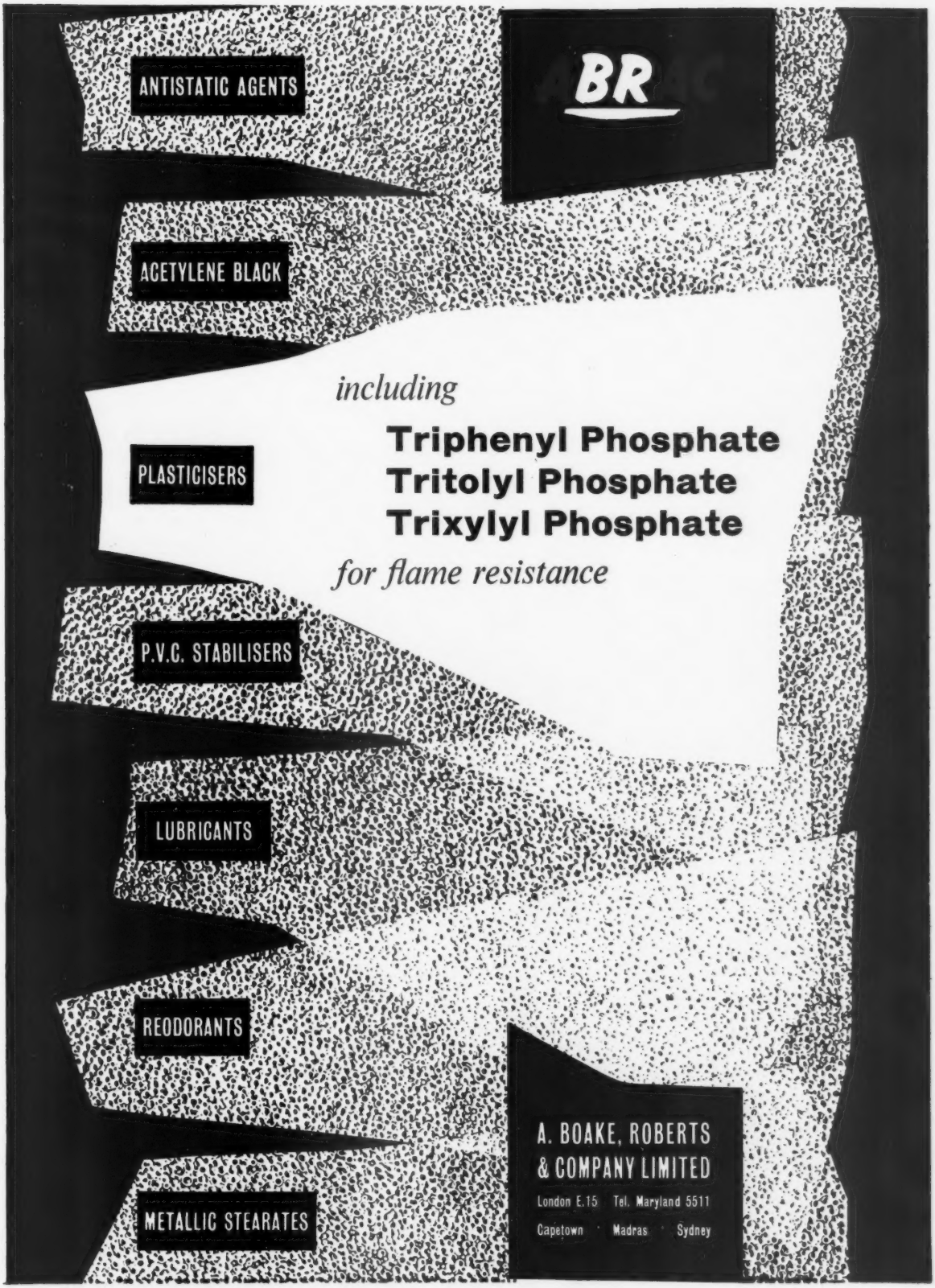
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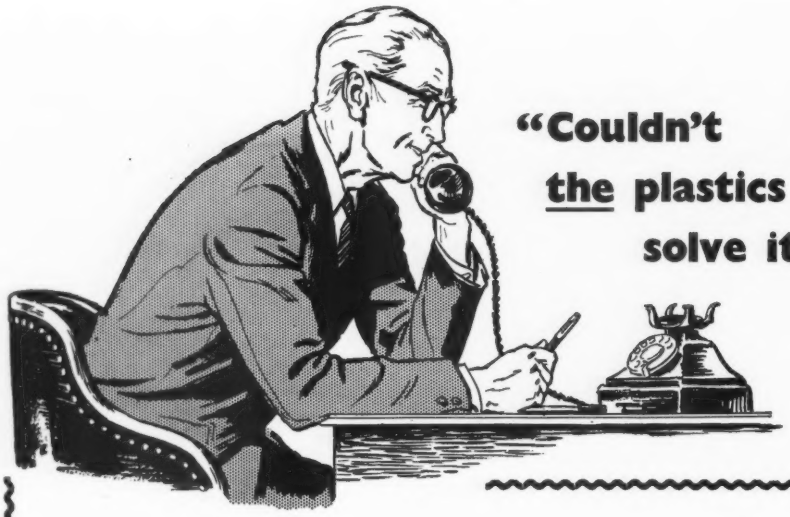

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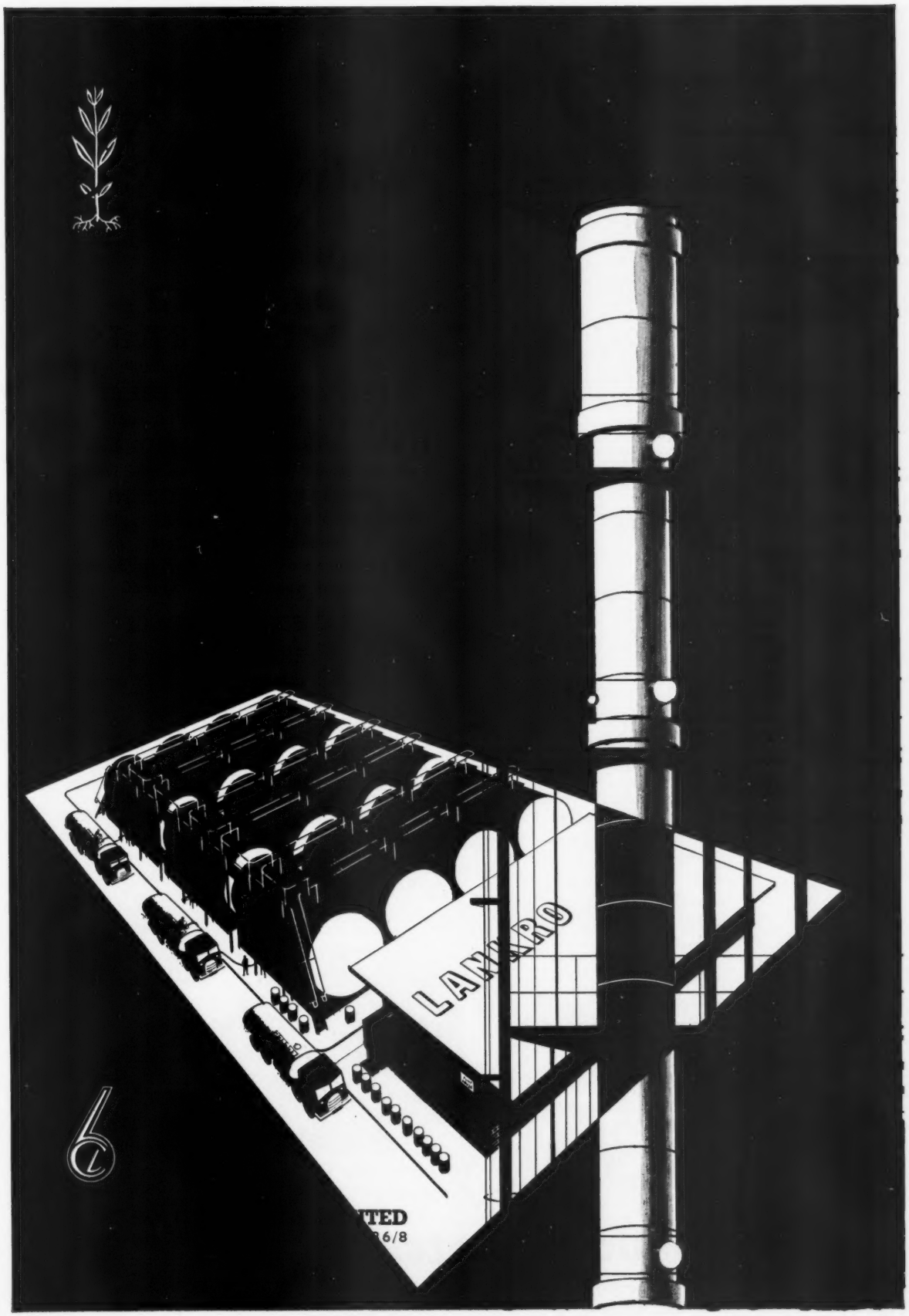
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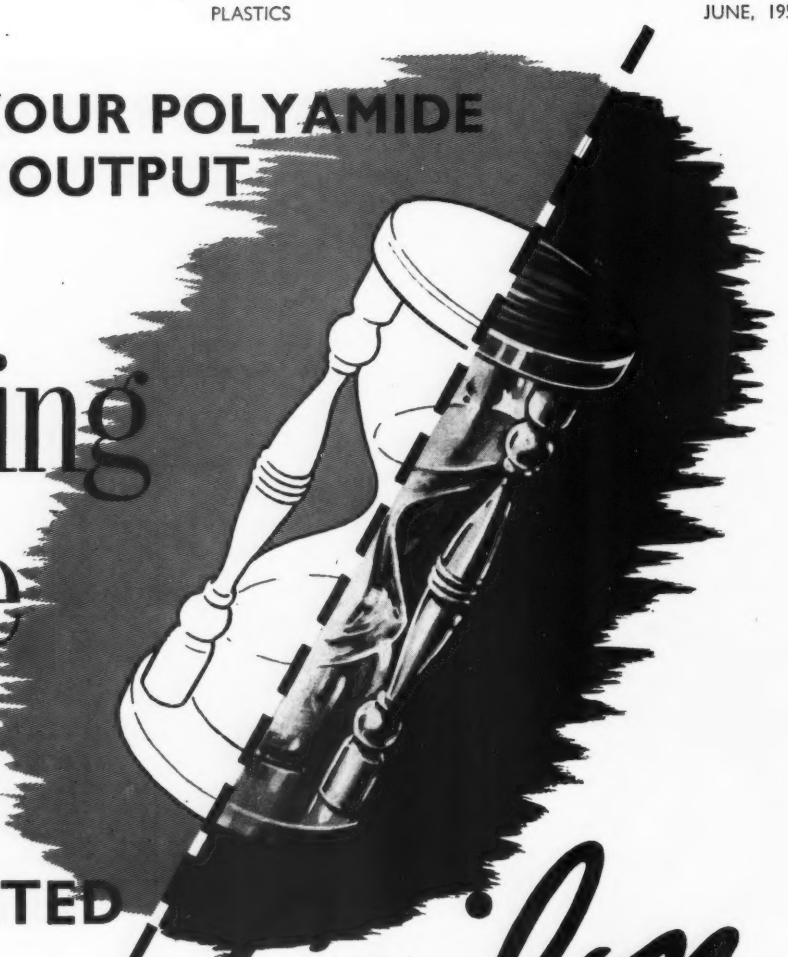

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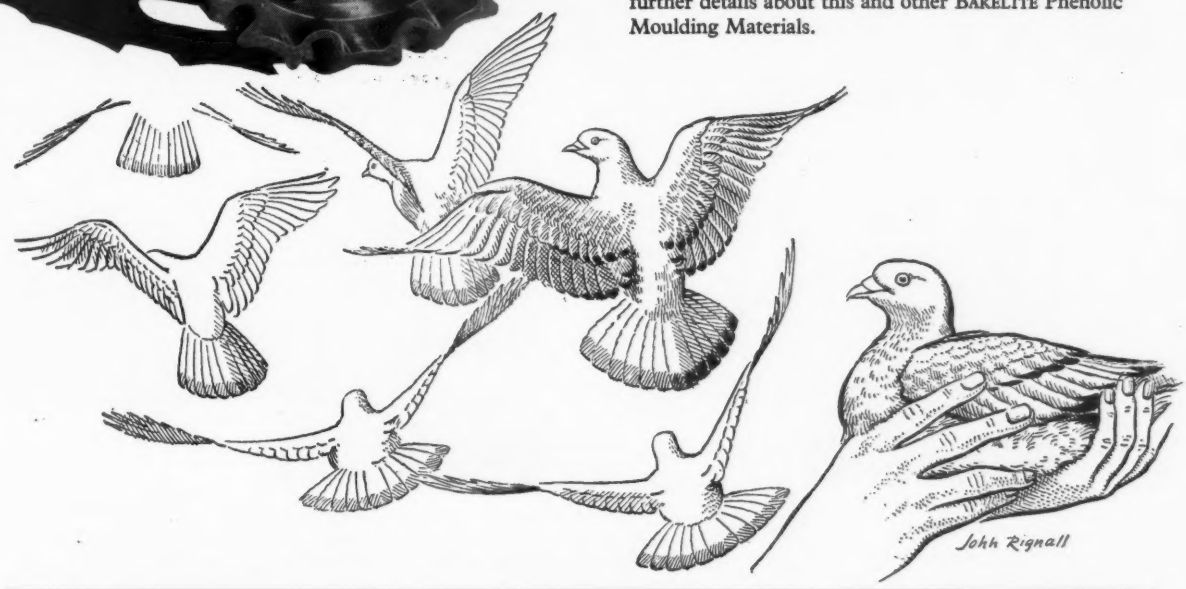

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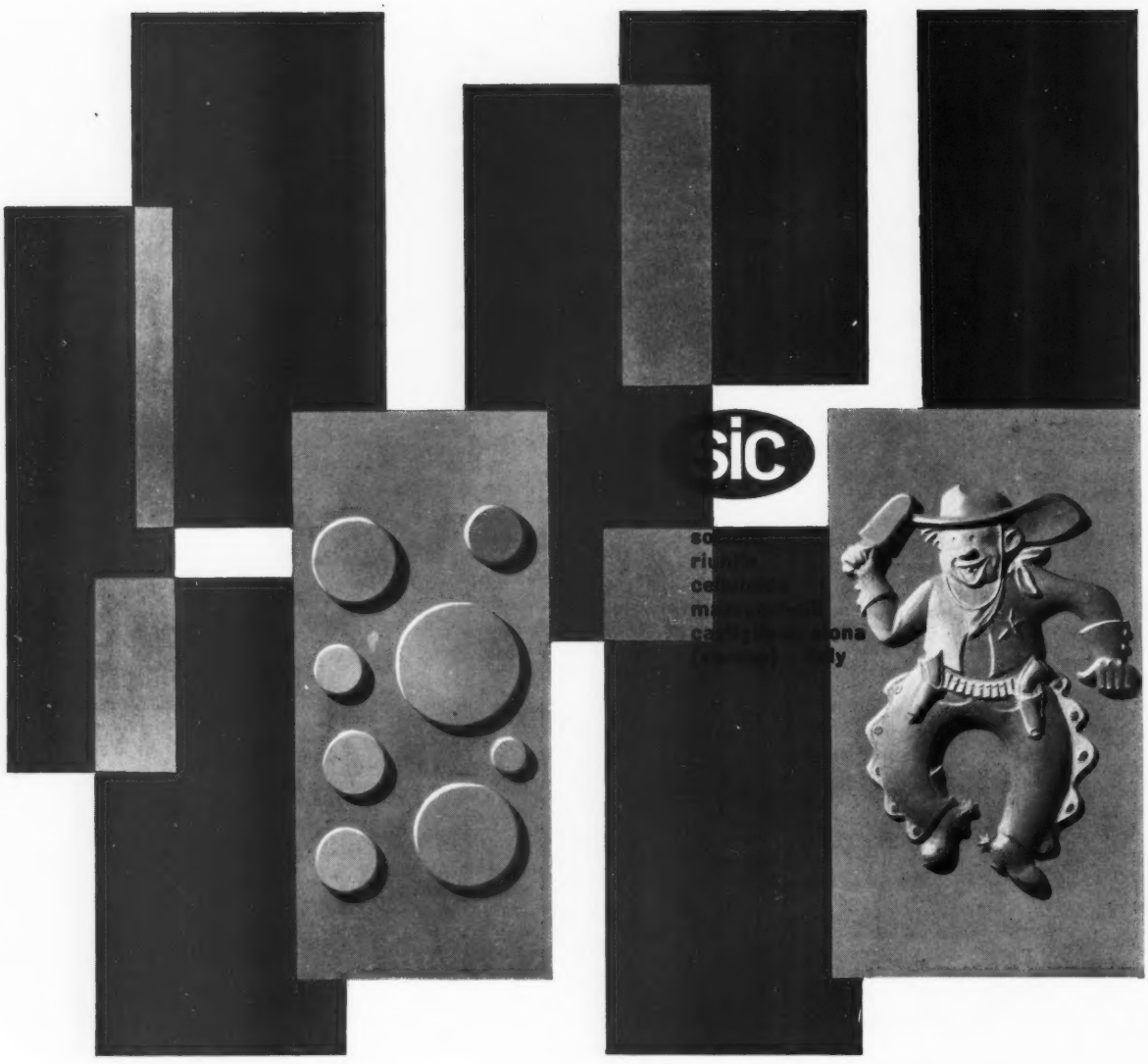

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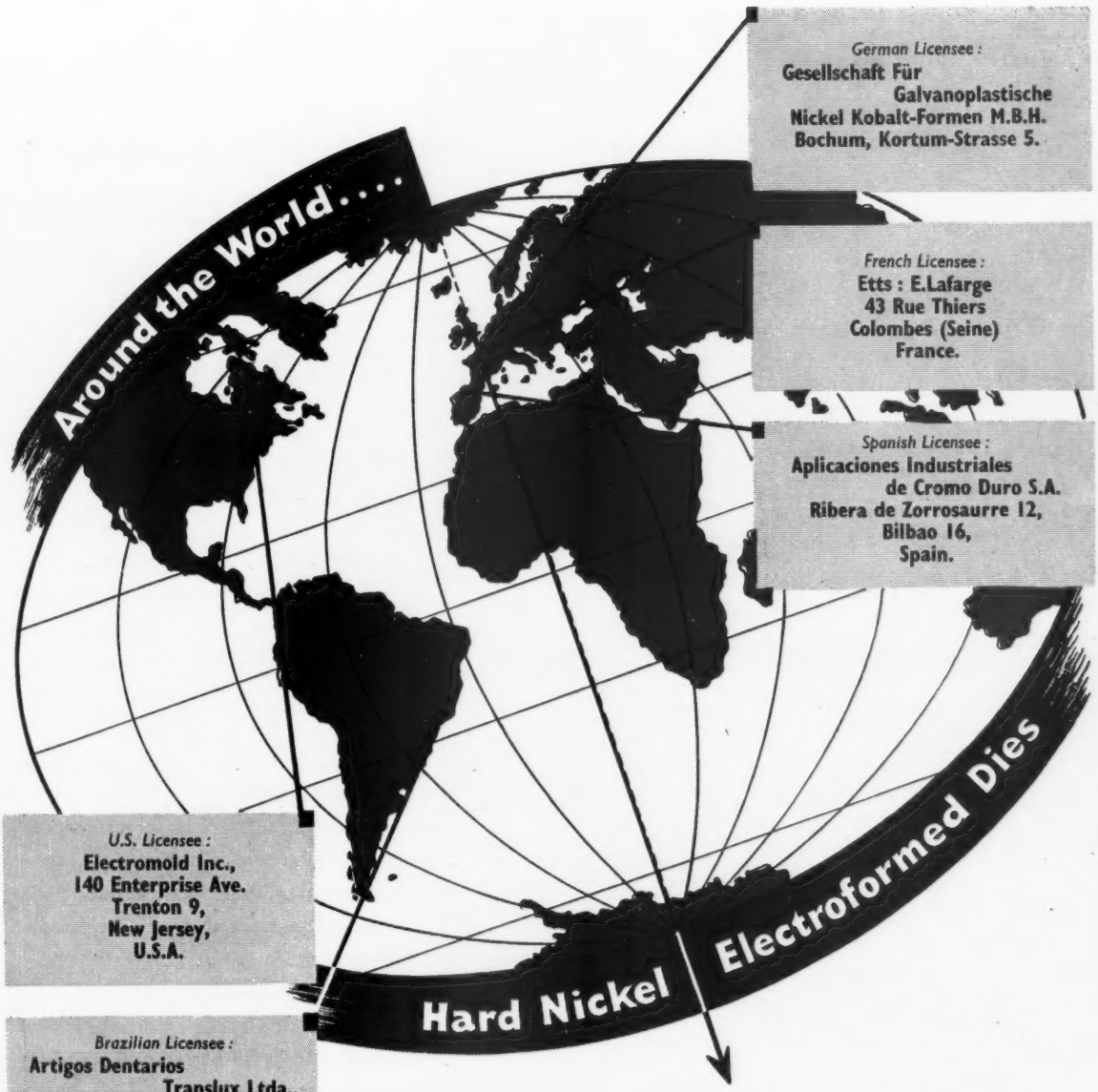

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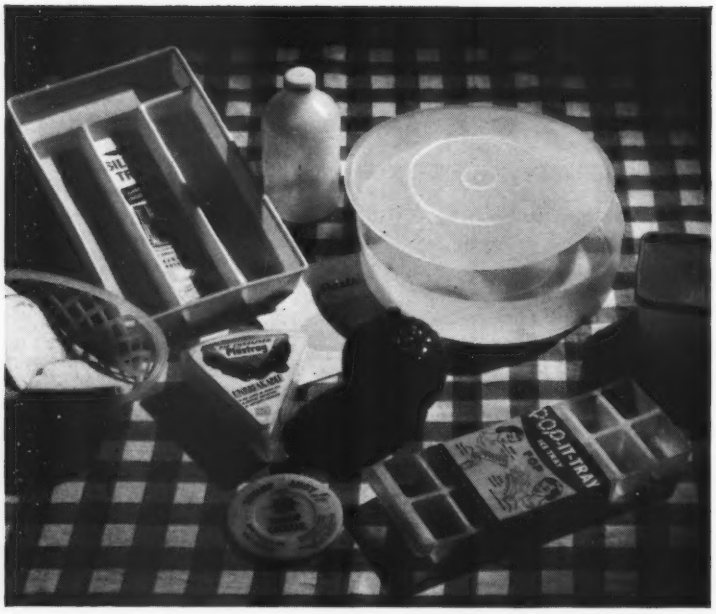

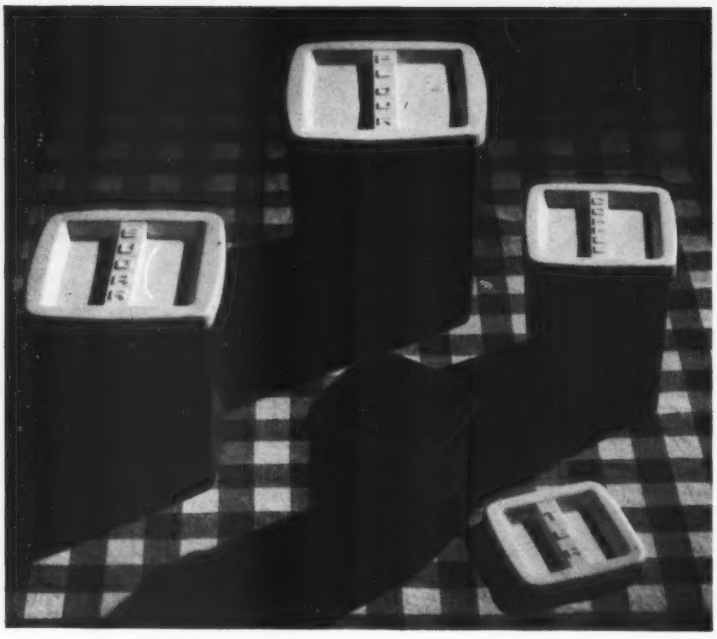

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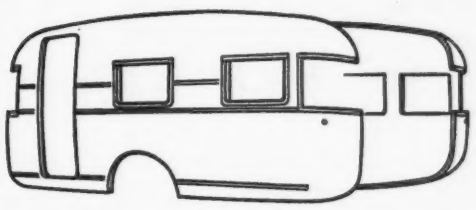
TGA PP2

TWO MOULDINGS make one Caravan!



The first caravan to be shown in Britain with polyester/glass fibre bodywork. Made by Berkeley Coachwork (Sales & Export) Ltd., using BAKELITE *Polyester Resins, it is 14′ 6″ long.*

The two large multicurvature mouldings which together form the outer shell of this modern four-berth caravan, were produced from BAKELITE Polyester Resins reinforced with glass-fibre. Combining high strength with light weight, components made from these materials are less vulnerable to damage than those made from conventional materials, and if damage should occur accidentally a repair can be effected easily and quickly. Polyester/glass structures can be produced simply and without special equipment, can be self-coloured or sprayed in the usual way, and are not subject to the forms of corrosion associated with metals.

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UNIFORMITY *of product*
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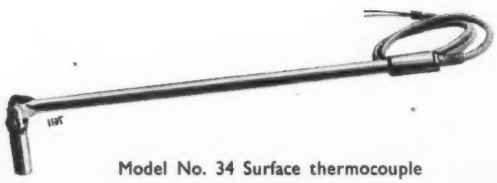

Model No. 34 Surface thermocouple

with

Cambridge SURFACE PYROMETERS

Taking temperature measurements on a plastic moulding press with a Cambridge Model No. 34 Thermocouple and Portable Type Indicator.

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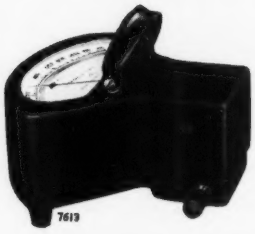

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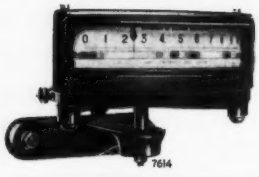

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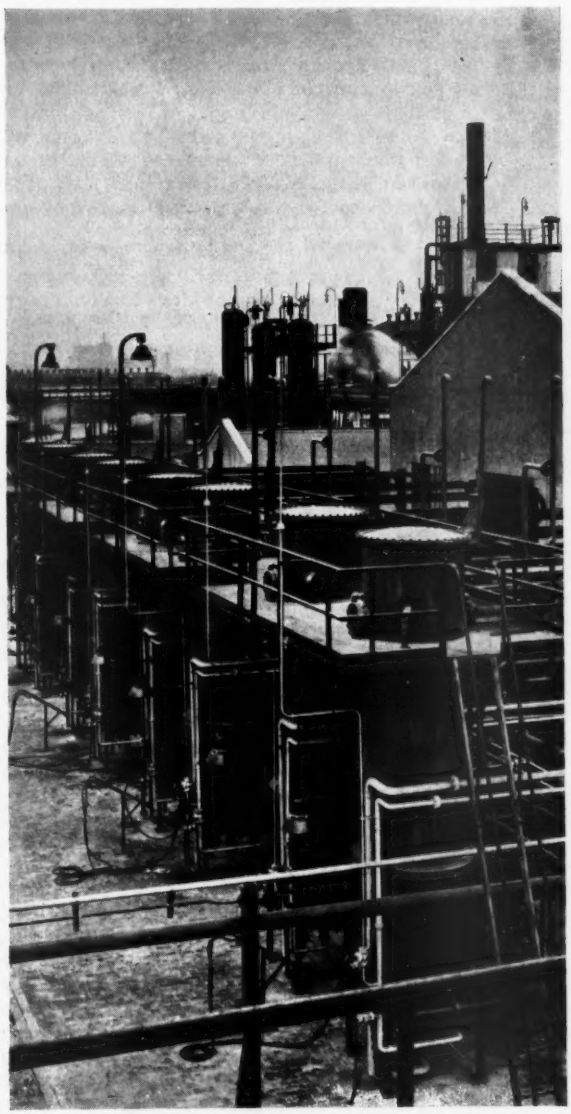

Extensions to p.v.c. plant of British Geon Ltd. at Barry, South Wales.

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EDITOR: M. D. CURWEN, B.Sc., A.R.I.C.
ASSISTANT EDITOR: C. W. WELCH

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Plastics

VOL. XXI. No. 225 JUNE, 1956

EDITORIALS

More About Petroleum Chemicals

LAST month was gratifyingly exciting in that two new and important laboratories were opened, both of which will have a strong bearing on the British production of chemicals and other products by the cracking of petroleum. The first are the Rideal Laboratories at Newport, Mon., named after Sir Eric Rideal the famous chemist who is now a director of the company. Here much pure research will be carried out including the reaction of gases and other compounds under radiation and a section for dealing with this type of work using Cobalt 60, is already in use.

We have already made public the production of polystyrene and detergents at Newport and also the more recent relations of Monsanto to the petroleum industry. A clearer conception of them is given in a pamphlet issued by British Hydrocarbon Chemicals Ltd. the new name of British Petroleum Chemicals Ltd. formed in 1947 as a joint interest by The British Petroleum Co. Ltd. and the Distillers Co. Ltd. to produce chemicals from petroleum at Grangemouth. In April, 1950, the company and Monsanto Chemicals Ltd. jointly formed Forth Chemicals Ltd. to produce styrene close by. In 1955, a third company was added to the group with the formation of Grange Chemicals Ltd., jointly owned by British Hydrocarbon Chemicals Ltd. and Oronite Chemical Co. of California (a subsidiary of Standard Oil Co. of California). The Grange Chemicals plant now produces dodecyl benzene, an intermediate for the manufacture of synthetic detergents. Broadly speaking, British Hydrocarbon Chemicals' plant programme was created to produce gases by the cracking of petroleum distillate, namely ethylene, propylene and derivatives therefrom including ethyl alcohol and isopropyl alcohol.

The more recent expansions began in 1955. They will provide for a duplication of the cracking plant and of the alcohol plant, a butadiene separation plant, a raw material for making synthetic rubbers, and for the production of tetra-propylene a raw material for detergent manufacture. Additional ethylene will be available for sale to Union Carbide Ltd. for the manufacture of polythene.

On May 3 we had the pleasure of visiting the new technical service laboratories of Shell Chemical Co. Ltd., the functions of which include the investigation of technical service problems on detergents, synthetic resins (notably the epoxy type), materials which now form an important part of the company's products. Thus in the synthetic resin section the equipment includes a varnish kettle and reactor and the adjacent surface-coating workshop is a paint factory in miniature. A constant temperature room is also available for testing plastics and paints.

The visit concluded with the opportunity of questioning a Shell Chemicals Brains Trust from whom we obtained information of the trend of future development. A pilot plant is already in operation using the Ziegler process for making polythene and it was clear that there is also considerable interest in polypropylene, the softening point of which is given as about 150° C. Other developments envisaged include, synthetic ammonia, styrene, and ethylene oxide.

Altogether very useful additions to our national economy.

The B.I.F.

CURIOUSLY enough, the first British Industries Fair was held in the middle of the first world war, in 1915, at a time when conditions, from every viewpoint, could not have been more difficult. It has continued as the pre-eminent of shop-windows of British industry, despite another world war and the recurring slumps of the 1920's and 1930's, until today. A few days before the opening of this year's exhibition, the Board of Trade announced that it would not, in future years, continue to sponsor the show. This means that the B.I.F. in London is finished, although we understand that the Birmingham Chamber of Commerce will continue to sponsor the Castle Bromwich section of the Fair.

The Board of Trade's decision was, we presume, dictated by the realization that industry was no longer supporting the Fair; in fact, there has been a steady decline in the number of exhibitors during the past few years. This last exhibition, already under sentence of death publicly before it opened, was depressing to exhibitor and visitor alike, and can hardly have offered a favourable impression to the overseas buyer. One cannot imagine such a dismal scene at Hanover, or Leipzig, or Dusseldorf.

However, London will see the B.I.F. no more, and the only representative exhibition for British industry as a whole, will be the surviving portion of the Fair at Castle Bromwich. Two points concern us therefore; is the curtailment of the exhibition likely to adversely affect the plastics industry, and if it is, will the Castle Bromwich section serve as a possible means for the rebuilding of the Fair into once again a truly national event?

Opinion is very divided on the first question. The industry sells much more of its products indirectly than it does directly to the public consumers, and the B.I.F. has never therefore had its complete support. The principal plastics exhibitors have been machinery and raw material manufacturers, with only a small sprinkling of moulders who marketed branded lines of goods, principally household items.

On the other hand, the total volume of plastic components shown at the B.I.F. has grown year by year, and the industry's stake in electrical and household goods must by now represent a major outlet for its moulding shops. Unless specialized exhibitions are now sufficiently all-embracing to ensure that all this country's products are adequately displayed, the overall trade position in consumer and capital goods may be affected. This must in turn have repercussions on the plastics industry.

As to whether Castle Bromwich holds any prospects for an eventual rebirth of the true concept of a British Industries Fair, opinions hardly need be canvassed. Whilst the site is good, Birmingham cannot be regarded as even remotely meeting the needs of a major exhibition centre. This year many overseas buyers were in hotels 40 miles away, there being not the slightest hope of accommodation in the city.

The fact is that the Castle Bromwich exhibition is already far too big for the resources of Birmingham. Only London can hope to absorb a major influx of people, and to provide a reasonably gay background of theatres and restaurants, desirable

if buyers are to be attracted from overseas.

The decision to end the London B.I.F. must remain therefore questionable, unless it can be shown that the plastics industry, in common with British industry as a whole, will not suffer.

And the Future

The decline in importance of the B.I.F. has been accompanied by the growth of specialized exhibitions. A detailed calendar of events in Britain would leave hardly a week free, including such subjects as factory equipment, radio components, the Purchasing Officers Minibition, mechanical handling, industrial clothing, stationery, and machine tools. With notable exceptions such as rubber, there are few industries, or facets of industry, that are not catered for. This pattern has been followed, to a lesser extent, abroad.

Is there scope (and several chemical manufacturers have already discussed this) for a national exhibition, either annual or bi-annual, at which the chemical industry could show its products on a scale compatible with its present-day status? Such an exhibition would permit the plastics raw materials manufacturers to demonstrate their wide contribution to industry as a whole, embracing not only mouldings, but textiles, leather dressing and the multitude of other products for which they are responsible.

MOULDING POWDER AND SHOT

Polyesters in U.S.A.

The Editor's notes on another page dealing with glass fibre polyester reinforcements, should certainly make a lot of people sit up, and somebody's sure to tell him not to wash dirty linen in public. I thought it pretty mild myself and while I don't hold much of a brief for him, I should say linen should never be allowed to get very dirty. However, what I wanted to say is that he might have noted the biggest U.S. outlets during 1955 in this field. This is the sequence: (1) Aircraft parts (20%); (2) domestic items, luggage, chairs (200,000); washing machines, etc. (20%); (3) boat hulls (18%); (4) corrugated roof lights and decorative sheet (15%). Much of the remainder was directed to the electrical field, switch gear parts, electric motor slot wedges, etc. The position of domestic ware is not unexpected in the U.S., but it must be very low down in the list here. The production of chairs here is not unknown as reception room equipment but in one example I saw some months ago, the seat had warped slightly and one of the four legs did not touch the floor. Pity the maker hadn't thought of making three legs only ! My spies tell me that the U.S. are making skis embedded with coloured designs and also dog kennels presumably with embedded paintings inside and out depicting the dog's Valhalla. What interests me most is that chemical equipment is being made on an increasing scale. Acid storage tanks would prove immensely useful especially as the stresses involved are not high or could be taken care of, and so would trays for the drying of acid salts and other acidic compounds; enamel and most metal trays are always a bit of a headache. But we must know about the real history of installations.

* * *

A Slight case of Vision

With the appearance of a number of new producers of plastic sheet specifically for vacuum forming, our recent articles on the subject of vacuum forming versus injection moulding have proved especially interesting. And foremost in the minds of vacuum formers is the possibility of diminution in price of sheet and the certainty that it would bring with it the chance of deeper entry into already existing fields and of nosing into new ones. A cited example is that of refrigerator units, which many companies produce from enamelled steel sheet. The process is complex entailing acid pickling plants, cleansing and de-rusting processes and finally high temperature ovens for enamelling. Many such companies would be only too pleased to throw overboard this process with its wastage due to imperfections, if they could be shown good reasons for doing so. Cost of plastics units would obviously be one factor, but at present, it does not appear to be near enough to " the point of no return." My spies tell me that one former is contemplating his own sheet extrusion from powder, a process which is already being employed in the U.S.A. and which I indicated a couple of years ago was the obvious corollary to the forming process carried out on a really big scale. If we let our imagination run riot, I suppose the quicker we arrive at more highly controlled polymers, improved heat transfer, close temperature measurement and control in the extrusion machine and electronic measurement and control of the issuing sheet, the quicker we shall get to automation. And of course we must look forward to really accurate and controlled heating of the sheet fed to the forming machine, the whole plant being enclosed in a factory with constant temperature, winter and summer!

* * *

Black day for me

'Pon my Sam! or should I say, 'pon my Victor Emmanuel? Thing's are coming to a pretty pass in this world! Here I've been going blissfully on, thinking I was the original inventor and discoverer of the title " Plastics in the Service of Man," the feature I started in this journal in 1949 and which still continues as thousands of our readers well know. I was considerably discomfited to find that after basking in the reflected glory of this apposite title for years, I have been fooling myself in somebody else's paradise. The real inventors were Dr. V. E. Yarsley the well-known plastics consultant and E. G. Couzens; their book, under exactly the same title, was published in the Pelican series way, way back in 1956! I must ask permission to continue our feature. Væ Victis!

* * *

B.P.F.'s New Baby

Went to a British Plastics Federation meeting last month and must offer my thanks to the Council for the invitation, the first occasion that " outsiders " have been present. I believe this new policy is due to the action of certain Chairmen of the Publicity Committee who had promised to get permission to " open up " on special " shows." This was one, the occasion being a meeting to gather information on the need for creating a special vacuum-forming section. Quite a number of vacuum formers in and out of the Federation and representatives of raw material manufacturers were present and while the meeting, at first, was rather woolly to say the least, things warmed up when there was a suggestion that the machinery in the Federation already existed to call together, when required, representatives of " appropriate " sections already in being: the fabricators and raw material manufacturers and machinery manufacturers. This did not satisfy some of those present, particularly Mr. A. B. Merriam who gave very clear reasons why, and insisted on a special section or nothing; a statement welcomed by most. The tone of the meeting at this point became quite exhilarating, and most enjoyable. I think Mr. Merriam knows what he wants and where he is going. Perhaps there will be a vacuum forming section. If there were a few more " free for all's " I think we should see a bigger membership.

DOGSBODDY.

Second Thoughts on Glass Fibre/Polyester Products

THE life of eight years of the glass fibre/polyester structure industry in Great Britain has not proved a brilliant one so far. It has been slow and chequered as was its life in the United States of America until a year or two ago. A recent resumé of French work in a French journal claims very poor results and stresses that only corrugated roofing lights have proved successful, which is an exaggeration but is indicative of the general disappointment. Germany, judging from the recent plastics exhibitions in that country shows no change from the general low level of production in Europe.

A more concrete view of the situation may be gauged from production figures. It has taken this country eight years to reach an output of some 1,500 tons of resin in 1955. Since there are some 9 or 10 polyester manufacturers here, there is no indication that the industry is in a healthy condition.

In the United States after a bad beginning the situation appears to have clarified somewhat and is much more flourishing, for the production 1955 was 22,000 tons, nearly double that of the previous year. The figure may include surface coatings but the rapid rise is encouraging. There are many productions in the American market which would not sell here, because of national characteristics or climates and there remains a proportion of poor work as bad as anywhere else; but there is a growing hard core of better quality structures and that is the healthy sign in the American scene.

The difference between the two countries lies in the courses of very recent technical history of the glass polyester reinforcement industry taken in both.

If we are permitted to be " elementary " at this stage, for the benefit of those who know little or nothing of this industry, we should point out that in the beginning, a liquid polyester resin was produced which on mixing with certain chemical agents, with or without heat, could be rapidly converted into a hard, insoluable, heat-resisting resin. It was also found that if impregnated into glass-fabric or glass mat or randomly placed glass strands, the final structure becomes much stronger.

Obviously the resin makers could not enter into the production of the finished shapes, which range from boat building, the making of randomes, electrical equipment and a hundred and one other desirable structures. Thus the resin and the processes had to be passed over to the manufacturers of such equipment, with what guidance was available. It is now quite clear that adequate guidance was absent; neither the resin makers who knew little or nothing about glass, nor the glass-fibre manufacturers who knew little about the resins, could advise in detail. More important still, here was a new technique unlike any other, and so with no precedents, which could only be carried out to even a semblance of efficiency by trained workers controlled by an individual, knowledgeable at least, in the general if not particular methods of chemical and physical technology.

Nor did the propaganda and publicity broadcast throughout the world by public relation officers and sales agents, ably supported by daily papers and not a few technical journals, provide more than confusion, for they loudly claimed the complete simplicity of manufacture, the cheapness of production, and the " strong as steel," completely indestructible properties of the finished goods. The truth of the matter is that the process is the very reverse of simple; it is a highly complex one, which, if not carried out with adequate knowledge, almost inevitably results in laminates of uneven properties and cannot, therefore, be regarded as productive of high quality engineering structures. A complicating factor is that to the non-technical even a low quality, technically weak structure may appear strong by cursory examination.

The Impregnation Process

The problem as presented to the user consists in (1) the mixing of a very viscous resin, the polyester, with a cross-linking compound generally styrene, a liquid closely resembling benzene in some characteristics. To this is added the catalyst, an organic peroxide which helps the initiation of the cross-linking reaction and so converts the liquid resin into a rigid solid one, and, if heat is not used yet a fourth chemical reagent termed an accelerator which speeds up the reaction. The accelerator is almost invariably cobalt naphthenate, an oil-soluble metal soap. It is absolutely essential that the catalyst must *not* be mixed together with the accelerator prior to mixing with the other two basic ingredients, the resin and the styrene, for heat is evolved by their simple mixture to a degree that can be dangerous. Thus the resin, styrene and say the cobalt naphthenate are mixed first and only when this mixture is homogenous, is the catalyst to be added and mixing continued. Mixture by this sequence of events makes the final composition completely safe.

Let us look close at the so-called simple mixing process. First, the formula of the composition is quite rigid from the point of view of the quantities to be mixed. It is also essential that the weighing of them be accurate. It is therefore quite absurd to expect untrained workers to carry out such an operation on kitchen balances especially when dealing with the accelerator which is required in very small quantities and which could be weighed in grams and even fractions of a gram. Obviously the weighing machine should be a works balance of reasonable accuracy and the mind and fingers trained to such accuracy. Above all in this respect, we must see an end of the possibility of a user saying very proudly, as he did to the writer " We don't stint the quantities here; we add 20% more cobalt than the books say," when such excess may affect the final result adversely.

We can now deal with the mixing process itself. Let us say immediately that perfect mixing of fluids is quite a difficult matter. Even the perfect mixture of hot and cold water, is not immediate but takes time and the chemical engineering industry has given much thought during the last 30 years to the construction of machines and in the design of agitators for carrying out the mixing process. The nature of the polyester mixture of viscous and non-viscous fluids demands especial care and patience, for on its homogenity depends the smoothness of the hardening reaction. It is not good practice therefore to place the ingredients in a biscuit tin and hope to get a uniform mixture by stirring with a wooden stick. If the biscuit tin is rusty there is an added danger to good work since iron is quite an excellent accelerator for the process of catalysis. These apparently small points are worth knowing when beginning on a small scale and must clearly be remembered when larger scale operations are reached.

(2) The impregnation of glass fibre with the resin mixture in a given ratio of weight of glass to weight of resin. The suggested use of glass fibre brought immediately into view the fact that there were available a woven glass fabric and, in its various forms, a glass fibre mat in which short strands are random-laid.

The fabric being a somewhat stiff, self-supporting structure seemed an admirable approach to normal technology in that there was an apparent analogy to the phenolic resin impregnation of paper or fabric and the hope of a continuous impregnation by the simple dipping and roller method. The very close weave however, the difficulty of " wetting " the glass fibre and of eliminating air bubbles around the fibres and between the fine monofilaments prevented the full impregnation of the resin and thus the attainment of maximum strength and of equal strength at every point in the area—an ideal which must be aimed at.

Nor could the impregnation be greatly improved by applying the resin with a brush and attempting to force it into the interstices. It must not be inferred that imperfect impregnations are useless. There are many structures thus made which are " adequately " strong for many purposes but they fall short of being what might be termed engineering structures.

The impregnation of a mat presents an immediate attraction, since its looser structure gives promise of deeper impregnation and the great advantage of the ease of production of multi- and irregularly-shaped objects without any theoretical limit as to size lay-up. Unfortunately, the only method of impregnating the resin into the mat so far devised is by means of a brush or roller and indeed by " punching " the resin in, and here again it is exceptionally difficult to wet the glass and " punching " can introduce tiny air bubbles into the resin and thus weaken the final structure. It is clear that perfectly even distribution cannot be achieved by such methods and so the finished structures is not of standard composition or strength throughout. The process cannot be termed anything but crude.

This then is the situation so far as it concerns the " wet lay-up " technique described above.

Pressure Process

It was soon realised that better results, mainly because of improved impregnation, can be achieved by the use of pressure in one form or another such as the use of matched moulds, of rubber bag technique with air pressure and so on. Indeed the improvement is seen in a great number of products and more especially in the production of relatively small units and components ranging from crash-helmets and electrical parts to chemical-resistant components made from pug-like mixtures.

In general, however, the normal lay-up previously described is employed and the resultant wet structure passed to the press. Obviously perfect impregnation cannot be attained by the relatively low pressure used, and furthermore since the system is still chained to the hand application of the liquid resin, the possibility of even distribution throughout the area is remote. Again, the time lag between the application of the resin and transfer to press if large contributes towards early-hardening and therefore against improved impregnation.

This strange mixture of crude working and comparative efficiency is brought out in the accompanying photograph which shows a rare accomplishment—the use of a huge press in the United States to make 15 foot dinghies. In Great Britain and Europe the process of production of a boat because of size invariably ends with the previously described lay-up process. This latter process is also employed more often than not in the U.S., but the important point is that the use of pressure in some form or other is now more common and is growing in American technique. Judging from the rapidly increased production in that country, in the gradually improvement of quality and increased range of products, it is certain that it has proved, with all its residual faults, an advance on the long road towards the production of high quality engineering structures.

The backwardness in adopting presses more widely in this country may be due to economic stringency, but it may also be related to too rigid adherence to the idea of apparent cheapness of the no-pressure technique.

The Next Step

If we agree that the wet lay-up method of impregnation is a technically inefficient one *per se*, and is common to both British and American processes whether pressure is used afterwards or not, such an agreement clarifies the situation but does not in itself create a solution. And unfortunately there is no new solution to the problem yet in sight, for as we have already indicated the problem of " wetting " glass is exceptionally difficult, a definite ratio of weight of glass to weight of resin for given structures must be adhered to, and the handling and distribution into areas of fibre of a viscous liquid is a complex problem. Improvements will be made scientifically and technically (e.g. a double impregnation has been suggested, using first a more hydrophilic and much less viscous " varnish " not necessarily of polyester resin, to give a thin and more adherent initial film, followed by the normal polyester to give the main desired characteristics). No doubt such improvements may prove more costly and slower, but it is clear at this stage we must arrive at basic principles.

It seems clear that until improved methods appear we must make do with present ones and that the most urgent need for this type of reinforcement industry is the installation of a system where potential users or their responsible representatives are trained in a general understanding of all the processes involved, including more exact methods of weighing and mixing, the clean and safe handling of resins, organic solvents and reagents, and even of the layout of a workshop that is virtually a small chemical factory, as conceived by a chemical engineer. There is no need to make chemists of such workers and indeed it cannot be done in a short time. But we can teach them to work to specification. It is by such training only that this process as it exists today can be lifted to a higher level.

If we believe this, we can rejoice at the action of one resin-

Here is an excellent American example of the author's argument—a mixture of extremely crude and good technology in applying a viscous resin to a glass-fibre preformed mat erected immediately under a huge modern press. The unit to be moulded is a 15 foot dinghy. While the technique is a considerable advance of British procedure, in that a mould is employed for this particular job, yet the laying-up of the mat and its treatment is similar. In Great Britain the process is known facetiously as the ' bucket and brush ' method. The Americans appear to be following the plasterers' technique. Seven men appear here without gloves and no doubt the interior of the female mould soon collects a high proportion of volatile solvent. A chemical engineer's nightmare !

producing company that has actually created such a school. For some months now British Industrial Plastics Ltd. at one of its Oldbury works has been training representatives of fabricating companies on the basis described. A recent visit to this school by the present writer amply convinced him of its value and displayed the realistic approach of the company in the face of existing facts and conditions. Every aspect of the technical production is taught, the straight lay-up and all forms of pressure work including matched-mould, rubber-bag and " paste " moulding technique. The plant includes also a large Bipel low-pressure press, and a modern electronically controlled vacuum preforming machine of large capacity and larger promise. We congratulate this company on initiating this movement and for giving us an early opportunity of announcing its operation. We believe that the Directors of the Company hope that its example will be copied for the general good and advancement of this promising but still hibernating industry.

Other Advances

It was on the tip of our tongue to say that the above movement is more important than continuous research in polyester resins. Such a statement only refers to the urgency and balance in the whole production set-up. There is little danger that polyesters, coupled with other advances, will not one day completely satisfy the technical demands. Modifications in them, to overcome difficulties in their inherent characteristics are being rapidly made.

But even that is not the only problem. Indeed the method of their catalysis is just as important and it is this side of chemistry and physical chemistry that has been woefully neglected, a fault common to the work in all countries. This work also applies to the understanding of the function of the accelerators, the search for new types other than metal soaps, and to the field of the metal soap itself. That only cobalt naphthenate is known and used in the industry is a strange commentary on present methods when it is well known in other related fields that different metals often have different effects and that the use of more than one metal can result in synergism and in improved results.

There is little fear also that the other essential component, glass fibre, will not eventually meet all the demands required of it by the industry. The " Volan " and silane treatment has already resulted in improved " wetting " and new methods of weaving (e.g. the Needle Loom type of mat seems to be yet another big advance) should also help in the same field. A recent visit by the writer to Fibreglass Ltd., to see the recently opened new laboratory with its excellent scientific and technical equipment and its splendid glass-fibre section gives hope of advancement in this country. We shall wait patiently to see what the next eight years bring. May they prove fruitful!

M.D.C.

LETTERS TO THE EDITOR

Correspondents are reminded that a stamped addressed envelope should be enclosed in all cases where a personal answer is desired. It is understood that any letter received may be published at the discretion of the Editor.

Education and Plastics

SIR,—I think that some of your readers are already aware that an active interest in education in plastics technology is a hobby of mine and that sometimes it may become a hobby horse. However, in view of the developments which are afoot in connection with technical education (White Paper, Cmd. 9703. H.M.S.O. 1/6) I would like to bring to the notice of the Plastics Industry, the scope of the Government's intentions.

According to the White Paper, during the next five years the Government's plans for developments in some 24 selected technical colleges include the spending of £70 million on buildings and £15 million on equipment in England and Wales, and £10 million and £2 million for like purposes in Scotland. Further the White Paper says, " The Government now wish to see the proportion of advanced work at these colleges vigorously increased, so that as many of them as possible may develop speedily into colleges of advanced technology."

The plastics industry should also be aware of the Hives Committee, that is a committee under the chairmanship of Lord Hives, engaged in the drawing up of proposals for the upgrading and general development of technical education. It is believed that the Hives Committee may be considering the possible development of the 24 technical colleges into technical universities and the granting of national diplomas in technology: it may well be that the granting of diplomas at different levels may be envisaged, such as a diploma for the " two year man," and a higher diploma for the " four year man." A " four year man " diploma would, it is suggested, be of similar status to a University bachelor's degree but with a technological bias.

It is known that the reasons for the Government's proposals for the development of technical education are based on a well founded belief that unless something radical is done quickly, this country will soon fall behind the United States, U.S.S.R. and Western Germany in technical development and manufacture and that our standard of living and way of life will not be maintained.

How does all of this affect the plastics industry? I would suggest in the following manner. Other industries with vigorous education policies will see to it that provision is made for large extensions in educational facilities in the technology of the particular industries and in consequence qualified technicians will be available for employment in the industries.

The plastics industry with its present timid approach to the development of technical education will not attract sufficient students to the technical colleges and hence an adequate supply of qualified technicians for its needs will not be available.

So far, I have dealt in generalties. For the moment, may I leave it at the assertion that before much can be done in the advancement of technical education in plastics the British Plastics Federation must be much more active both in financial support and participation in planning for the future.

May I say in closing that it is imperative that something should be done, and I for one think that something can be done.

C. A. REDFARN.

Quality House,
Quality Court,
Chancery Lane,
London, W.C.2.

Coating Hygroscopic Crystal

SIR,—We wish to coat a hygroscopic crystal of low melting point with a thin film of polystyrene. We believe that an equipment is marketed in this country consisting of a heated spray gun, similar in principle to the system used in metal spraying. Can you tell us the manufacturer's name and address, and also advise us on the process?

BRUSH CRYSTAL CO., LTD.

Hythe, Southampton.

Fluted P.V.C. Tubing

SIR,—We are having difficulty in finding a source of supply for coloured flexible p.v.c. tubing of ¼-in. bore with fluted exterior surface and we would be grateful for any advice you may be able to give us.

HENNESSEY PRODUCTS (HAMPSHIRE), LTD.

Lustralux Works,
11 South Street,
Havant.

Drum-coating Lacquer

SIR,—In our interest in coated metal drums we have come across the term " H " lacquer. We would be most grateful if you would let us know what type of lacquer this is and whether it is available for general use.

GESTETNER, LTD.

Tottenham,
London, N.17.

The British Industries Fair, 1956

Plastics Materials and Fabrications Prominent at the London and Birmingham Exhibitions.

THIS year's B.I.F., the subject of editorial comment elsewhere in this issue, opened in London under the most unhappy conditions, in that it had been announced a few days before, by the Board of Trade, that the London section of the B.I.F. was not to be held in future years. Whilst this unfortunately timed statement probably did not deter the overseas visitor, it most certainly had a profound effect upon the home buyer. Olympia was almost empty for many periods during the Fair and Castle Bromwich was only a little better attended.

It is not, however, necessary here to comment on what are really matters of opinion and we are only really concerned at this point with giving a factual account of the B.I.F. as it represented the British plastics industry.

For several years now the industry as a joint body has become steadily less and less interested in the B.I.F., but in spite of this, the overall representation of the industry at the exhibition has, during these years, progressively increased. This year's Fair was no exception, and in many cases the plastics exhibits reached a level previously unattained in Britain. In addition, there were several exhibits that were unique in their way, each of them worthy of special mention.

In the framework of the report that follows, which is largely pictorial, we have employed the stand by stand review system, as a selective commentary covering the London and Birmingham sections separately.

London's B.I.F. is dead and the future of the Birmingham section will be problematical; whatever the future, however, plastics were well to the fore at this exhibition.

London Section—Chemicals and Materials

INTEREST in melamine tableware and laminates for catering establishments, hospitals and in the home, has developed rapidly. Other domestic uses for melamine mouldings include ashtrays, knife handles, buttons, draining boards, aerosol containers, and electric razor housings. Many of these applications were shown on the stand of the **British Oxygen Co. Ltd.**

Samples of dicyandiamide, polyvinyl acetate emulsions and polyvinyl pyrrolidone were also exhibited, together with some of the products which are made from them.

On the stand of **A. Boake, Roberts and Co. Ltd.**, a special feature was made of a relatively new product, Abrac 'A'—an epoxidized oil stabilizer with plasticizing properties for vinyl chloride polymers. Abrac 'A' is an outstandingly efficient stabilizer for resins and polymers which, on exposure to heat or light, liberates acidic degradation products. It is particularly effective with those polymers which liberate strong acids such as hydrogen chloride: it is, therefore, being used on an ever increasing scale with polyvinyl chloride and its copolymers. It is compatible with all grades and types of vinyl chloride polymers—including paste-forming resins—and imparts excellent stability to heat and light when used as the sole stabilizer, or as a component of synergistic mixtures. The use of Abrac 'A' is not restricted to polyvinyl chloride: it is also of interest as a stabilizer for chlorinated rubber, chlorinated waxes, etc.

A general view of the stand of Petrochemicals Ltd.

A feature of the exhibit of **John & E. Sturge Ltd.**, Wheeleys Road, Birmingham, 15, was a glass-fibre reinforced plastic car body, loaned by Martin Plastics (Maidstone) Ltd. A special grade of Sturge precipitated calcium carbonate, Calofil 'A.4', is used as an extender for the polyester resin. Calofil 'A.4' is a low oil absorption filler coated with 1% resin; comparatively high loadings can be achieved without increasing the viscosity of the paste by too great an extent. Other advantages are that Calofil is chemically produced to a fine particle size and there is no danger of settlement at normal loadings. Calofil is white and does not cause staining and, being non-abrasive, does not cause wear on tools.

Her Majesty the Queen visits the Monsanto stand. Sir Miles Thomas, chairman elect of the company, presents the Queen to Mr. D. R. Mackie, newly-appointed managing director.

Also illustrated was the use of precipitated calcium carbonate as a filler for p.v.c. Calofil 'A.4' is used for paste resins while several grades, notably Calofort 'S', can be used for compounds for moulding, calendering and extrusion. Calofort 'S' is stearate coated and the ultimate particles are below 0.1. microns. The special advantages claimed for Calofort 'S' are that it reduces folding white and helps impart a glossy, scratch resistant surface.

Another Sturge exhibit was citric acid—produced by industrial mould fermentation—and used in the manufacture of plasticizers and resins for the plastics industry.

Materials

Many of the uses of Styron polystyrene, which is manufactured by **Distrene Ltd.** at Barry, Glamorgan, were featured. The Distrene plant which only came into full production recently is regarded as the most up-to-date polystyrene plant in the world.

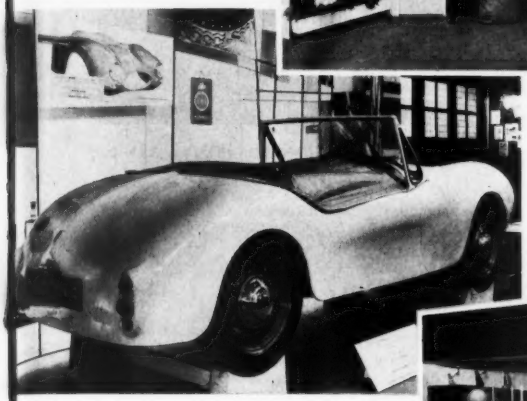
The main feature of the **British Resin Products Ltd.** display was the new range of Epok and Cellobond polyepoxy resins. The exhibit was designed to illustrate the wide variety of uses of these resins in the surface coating and other fields. Cellobond polyester resins are also being increasingly employed in many branches of industry. A selection from the numerous applications of this important group of B.R.P. resins was shown.

The display of W. J. Bush and Co. Ltd.

B.I.F. OLYMPIA

(Right) Hercules Powder Co. Ltd.

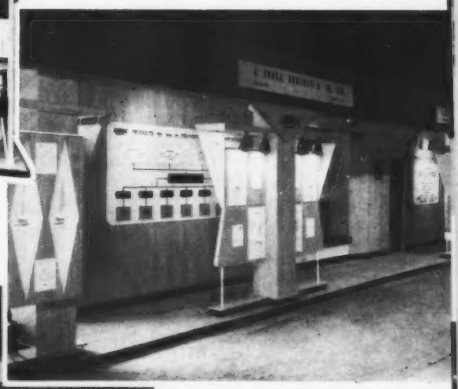
(Below) Martin Baker car on the stand of John and E. Sturge, Ltd.

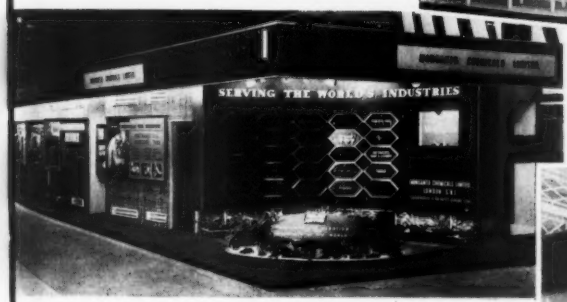


(Above) The display of British Resin Products Ltd.

(Right) B.X. Plastics Ltd.

(Below) Monsanto Chemicals Ltd.

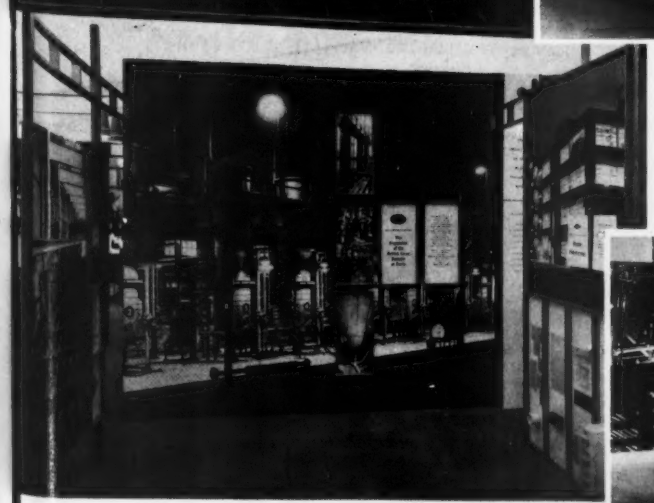




(Right) Albright and Wilson Ltd.

(Above) A. Boake Roberts and Co. Ltd.

(Below) British Oxygen Co. Ltd.



(Above) The British Geon Ltd., exhibit, on the stand of the Distillers Co. Ltd.

(Left) Chemical tank on the stand of Bakelite Ltd. An industrial grade of p.v.c. faced with polyester/glass was used.

The **Hercules Powder Company Ltd.** stand at the British Industries Fair was based on the theme "Wherever you may be, Hercules is there". A selection of the company's products manufactured in the U.K. was displayed, and a wide variety of examples of common everyday uses of these products was provided in accordance with this theme.

The section of the stand of particular interest to the plastics industry was concerned with the uses of cellulose acetate. Three contrasted outlets for Hercules cellulose acetate were illustrated, covering a variety of uses such as steering wheels, door handles, and the like, used in transport, a selection of garments made from acetate yarn, and a display illustrating the uses of cellulose triacetate in photographic film.

Given prominence on the stand of the Plastics Division of **I.C.I. Ltd.** was Fluon, rapidly gaining ground in many industries, particularly in the manufacture of chemical plant where it is used for packing, valve seats and seals.

Epoxy resins, recently subject of an international symposium, were given prominence on the stand of the **Shell Chemical Company Ltd.**

The general theme "Chemicals from Petroleum" constituted the keynote of the exhibit by **Petrochemicals Ltd.**

Midland Silicones Ltd. had a display in the chemical section designed to stimulate the interest of overseas buyers in Silicone resins. Over 30 new products were put on the market for the first time last year.

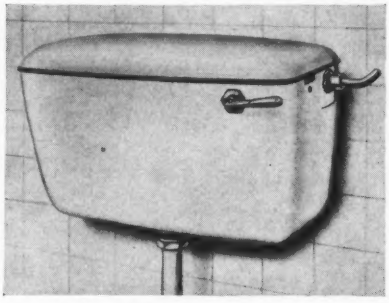
Castle Bromwich — Chemical Plant Reinforced Plastics, Household Goods

FUME extraction plant illustrating some uses of non-corrodible vinyl plastics, were shown by **B.X. Plastics Ltd.** The exhibit consisted of three component parts: (1) A steel tank lined with vinyl sheeting. This was laminated Cobex rigid vinyl and Velbex flexible vinyl sheet with the Velbex face adjacent to the metal. The laminate was used because the flexible material overcomes to a large extent the difference in thermal expansion of the material and the metal thus giving a better adhesion, whilst the rigid vinyl has the better chemical resistance. The internal joins were all welded with vinyl rod so that an unbroken non-corrodible surface was provided. This unit was fabricated by A. E. Griffiths (Smethwick) Ltd. (2) Lip ducting, trunking and cowl all in Cobex rigid vinyl sheeting, joints welded with Cobex rod. Designed and fabricated by Prodorite Ltd., Birmingham. (3) Bifurcated fan fabricated by Tanks & Linings Ltd., Droitwich, for Keith Blackman Ltd. All the parts exposed to corrosive media are made from Cobex rigid vinyl in sheet form or machined from solid blocks.

The whole exhibit is to be set up in the Industrial Health and Safety Centre to demonstrate to visitors from study groups, industrial welfare societies, individual firms and Government departments some of the uses of vinyl sheeting in connection with industrial health and safety.

Reinforced Plastics

The largest single display of polyester/glass mouldings ever assembled in Great Britain was on view at the stand of **Bakelite Ltd.** The mouldings ranged from crash helmets for motor cyclists to complete caravan bodies, and included structural components for a dozen major industries. All had been produced from Bakelite polyester resins reinforced with glass fibre, which provides great strength allied with lightness, corrosion resistance and unlimited colour possibilities. The display included two complete caravans; a sports car; a Morris Minor hard top; a front cowl for the United Dairies electric delivery vehicle; moulded fronts and other components for motor buses; a motor launch; a dinghy; ducting and other



The new white moulded cistern by Shires and Co. (London) Ltd.

structural mouldings for the Vickers Viscount; concrete pipe clad with polyester/glass which will withstand bursting pressures of 200 lb./sq. in.; plating tanks for the chemical industry; crash helmets; cafeteria trays; machinery guards; dye tubs for the textile industry.

Household Goods

Fraser and Glass Ltd. had an extensive display of Fethaware household equipment manufactured primarily from polythene.

Examples of melamine used to mould tableware. Shown by British Oxygen Co. Ltd.

Household jugs moulded in H.D. polythene by Halex.

An interesting display was shown on the stand of **Mody and Co. Ltd.,** featuring the use of Shell epikote resins for surface coatings for a wide variety of products, including deep freeze equipment.

Of the many features on the stand of **I.C.I.'s Plastics Division,** the Maranyl range of nylon moulding compounds was worthy of special mention, for such diverse applications as textile pickers and hypodermic syringes.

The **Halex Division** of the **British Xylonite Company Ltd.** showed many new lines, including products from the Peco 160 oz. machine. Attracting special attention were such items as a polythene tub 24½ in. in diameter and a polythene bin, 16⅜ in. in diameter. Several mouldings were also shown in the new high-temperature resistant grades of polythene.

Door furniture was specially featured by **Plasticraft Products (Darwen) Ltd.,** utilizing a number of plastics materials particularly pearlescent perspex. **Latymer Engineering Co.** created special interest with their latest types of automatic vacuum forming and drape forming machines and showed excellent examples of products with their equipment.

E. K. Cole Ltd. displayed a large selection of mouldings used by many of Britain's leading industries and also the range of Ekco Gold Seal domestic ware. Amongst the latter were included ice chippers in polythene and flower sprays in polystyrene.

Three dimensional badges used by the motor and refrigeration industry were shown by **Clearex Products Ltd. Aeraspray Associates Ltd.** showed new equipment incorporating a double headed spray gun for the application of polyester resins.

The **Gourock Rope Work Company Ltd.** showed examples of p.v.c. coated cloth in foul weather clothing and other applications.

Fawcett Finney Ltd. displayed the Davis-Standard extruder complete with all equipment for the high-speed covering of wire. For full details see pages 133 to 137 of this issue of *Plastics*.

The catering trade will have been interested in the display of **Phipps Plastic Products Ltd.,** which made extensive use of Perspex, cellulose acetate and p.v.c.

Celebrating their jubilee this year, **George Ellison Ltd.** had a joint display on which was featured products of **Tufnol Ltd.** Components made from Tufnol included electrical insulators, gearwheels and marine fittings.

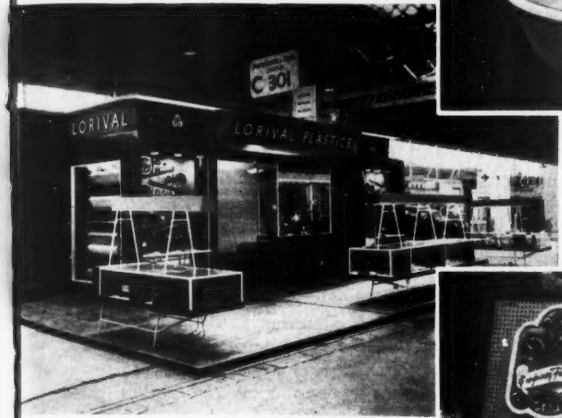
Laminates for the industry was the keynote of **Permali Ltd.,** who showed amongst other items the Mitchel hot air drying oven incorporating Permali moulded drying trays.

The special feature on the D.S.I.R. stand was a nylon conveyor chain manufactured by **British Rawhide Belting Company Ltd. Prodorite** displayed examples of chemical plant manufacture with the aid of p.v.c. and polythene.

(Left) Vacuum forming equipment on the stand of Latymer Engineering Co.

(Above) E. K. Cole display of mouldings for the home.

(Right) Tub and bin in polythene, shown by Halex.

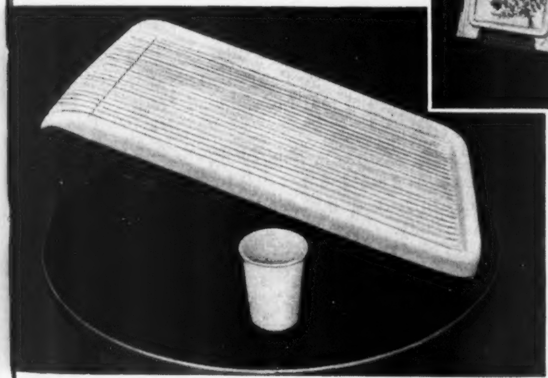


(Above) Lorival Plastics.

B.I.F. CASTLE BROMWICH

(Above) Industrial equipment fabricated in Cobex, on B.X. Plastics stand.

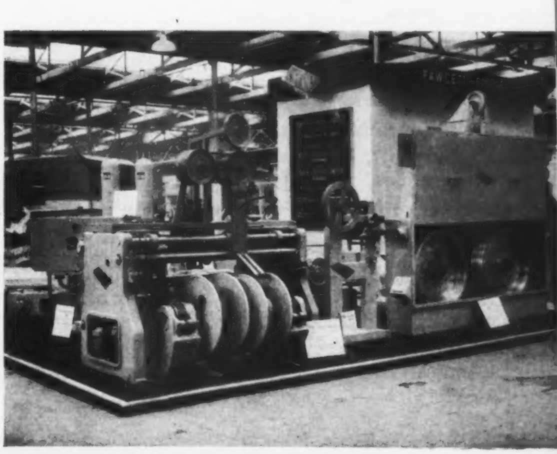
(Above) Vacuum formed advertising plaques shown by Latymer Engineering Co.



(Above) Draining board and mug in polythene, shown by Halex.

(Above) Bakelite Ltd. The biggest display of glass reinforced plastics ever.

(Below) I.C.I. features nylon for moulding.



(Above) High-speed wire covering equipment shown by Fawcett-Finney Ltd.

Progress with Alkyd Moulding Powders

Comparisons with Standard Thermosetting Compounds for Electrical and other Applications.

THE plastics industry first heard of alkyd moulding powders in 1948. The original research was carried out in the U.S.A., and for a long while we in Britain saw little of this apparently promising group of materials. By 1952, however, it became clear that work in Britain was also in progress, and that furthermore, there was a distinct difference in approach. Whereas the Americans appeared to be concentrating on the fast-moulding characteristics, Britain was concentrating on the superb electrical and heat resistant properties possible with alkyds.

This aspect was high-lighted by an article in *Plastics* in March, 1955, by G. Bell and J. A. Willey, which, whilst directed towards electrical applications, gave much useful information on cure times, water absorption and heat stability. British work has been carried out by Bakelite Ltd., and Resinous Chemicals Ltd., the latter company working on the Plaskon patents and processes. Moulding experience has also been obtained by a number of British companies, and the experiences of one, Insulators Ltd., were reported in *Plastics* for September, 1955, pages 299–301. Here attention was founded on contactor bases and hoods moulded for Arrow Electric Switches Ltd.

TABLE 1*

POWDER PROPERTIES AND MOULDING PROPERTIES OF SOME THERMOSETTING ELECTRICAL GRADE MOULDING MATERIALS

Property	Alkyd		Mineral-filled	
	Standard cure	Fast cure	Phenolic	Melamine
POWDER—				
Shelf life	Good	Fair	Good	Fair
Pelleting properties	Fair	Good	Good	Good
Bulk factor	3.0–4.5	2.0–2.2	2.0–2.5	2.0–3.0
MOULDING—				
Time to give blister-free flow cup (sec.) at 163° C.	60–75	15–30	75–100	70–100
Moulding versatility	Good	Poor	Good	Fair
Hot strength	Poor	Fair	Good	Good
Rigidity on ejection	Fair	Good	Good	Good
Resistance to cracking round inserts	Good	Poor	Poor	Poor

With the literature issued by the powder manufacturers, therefore, plus the articles published in the technical press, we have passed beyond the early stage where the materials were curiosities, to the point where reliable forecasts may be made as to their future. Until a few weeks ago, however, we were still waiting for an authoritative review of the complete field, and more especially a scientifically evaluated comparison of important properties between the alkyds, phenolics, ureas and melamines.

This review came in the form of a paper written by J. H. Bennitt, A. L. Ashton and D. M. Jonas, and read by Mr. Bennitt before the London Section of the Plastics Institute, on April 26. Mr. Bennitt, Mr. Ashton and Mr. Jonas are of the Research and Development department of Bakelite Ltd.

The paper, entitled "Alkyd Moulding Materials and their Applications," will be published in an early issue of the Plastics Institute Transactions, in full, and we are most grateful to the authors, and to the Plastics Institute for permission to use some of the contents in this present review of the situation. Since we have compiled this primarily for the benefit of moulders and their customers, it may be as well to re-state the properties claimed for alkyd moulding powders.

Firstly, and most important, they are noteworthy for their electrical characteristics, especially arc resistance and anti-tracking. They also stand out for dimensional stability, heat resistance, low water absorption, chemical resistance, inertness to attack by fungus, and availability in any desired colour. They can also offer faster cure times, although whether this can be regarded as a competitive advantage is in doubt. The economic advantage of the faster cures has been discussed by Mr. Bennitt.

The chemical constitution of these materials is largely responsible for the favourable properties exhibited. Basically they are formed as the combination of polybasic acid derivatives, such as maleic anhydride, and polyhydric alcohols, typically ethylene glycol. These materials, when reacted together form unsaturated polyesters which undergo additional polymerizations in the mould cavity, accompanied by an exotherm. No volatile by-products are formed, and this accounts for the stability of the resultant mouldings and also the rate of cure.

At first sight, the list of properties noted above is so favourable as to make the alkyds practically supreme in the field of thermosetting powders. However, as the following notes will show, based as they are on Mr. Bennitt's address, there are several factors to be noted, not least the question of price.

There seems little hope that alkyds will ever be less than substantially more expensive than melamines, ureas and phenolics. This one factor at once places a limit on their widespread usage, *except* where these special properties make them desirable. They should therefore be regarded as an addition to the range of thermoset moulding compositions, and not as competitors to any one of them.

With this point in mind, it is apposite to note that alkyds embrace four main types of material, each with special characteristics. Mr. Bennitt lists them as follows:—

(*a*) Electrical insulating materials with moulding versatility.
(*b*) Fast curing electrical insulating materials.
(*c*) Special purpose electrical insulating materials, for example, self-extinguishing and high impact grades.
(*d*) Decorative materials.

To the moulder, the advantages of group (*a*) are the good all-round properties of the alkyds and the fact that they can be used in conventional equipment. A disadvantage is that they are somewhat weak mechanically.

For group (*b*) special fast-closing presses are required if full

TABLE 2*

MOULDED PROPERTIES OF SOME THERMOSETTING ELECTRICAL GRADE MATERIALS

	Alkyd		Mineral-filled	
	Standard cure	Fast cure	Phenolic	Melamine
MECHANICAL—				
Specific gravity	1.6–1.8	2.0–2.2	1.7–1.9	1.7–1.9
Impact strength (ft. lb.) ...	0.01–0.20	0.10–0.15	0.10–0.15	0.10–0.20
Tensile strength (lb./sq. in.)...	4,000–5,000	3,000–4,000	4,500–7,000	4,000–6,000
ELECTRICAL—				
Track resistance	Excellent	Excellent	Fair	Excellent
Power factor at 800 c/s (%)...	3.0–6.0	2.0–5.0	1.5–5.0	5.0–10.0
Electric strength at 90° C. (v./mil.)	250–300	250–350	200–400	100–200
Surface resistivity after immersion (ohms)	10^{11}–10^{13}	10^{13}–10^{14}	10^{12}–10^{14}	10^{11}–10^{13}
STABILITY—				
Water absorption (m.g.) ...	40–60	40–100	10–50	30–70
Shrinkage after 14 days at 150° C. (in./in.)	0.001–0.002	0.001–0.002	0.0005–0.0015	0.008–0.012

TABLE 3*

COMPARISON OF THE PROPERTIES OF REINFORCED AND GENERAL PURPOSE ALKYDS

Property	Reinforced	General purpose
Bulk factor	6–12	2–4.5
Specific gravity	1.7–2.2	1.7–2.2
Time to give blister-free flow cup at 163° C. (sec.)	30–60 (f)	15–30 (f)
	120–180 (s)	60–75 (s)
Impact strength ft. lb.	2.0–5 0	0.10–0.20
Tensile strength (lb./sq. in.)	5,000–7,000	3,000–5,000
Track resistance	Excellent	Excellent
Power factor at 800 c/s (%)	2.0–6.0	2.0–6.0
Electric strength at 90° C. (v./mil.)	250–350	250–350
Surface resistivity after immersion (ohms)	10^{9}–10^{13}	10^{11}–10^{14}
Water absorption (m.g.)	50–120	40–100
Shrinkage after 14 days at 150° C. (in./in.)	< 0.001	0.001–0.002

f = Fast cure. s = Standard cure.

economic advantage is to be obtained. The properties of mouldings are similar to group (*a*).

Under the heading of group (*c*) fall specially modified compounds, made to individual requirements, such as self-extinguishing, high impact, and the stiff putties used when moulding round delicate inserts.

In group (*d*), combinations of alkyd resin and purified wood pulp, we have a range of compounds with the decorative possibilities of the amino-plastics, plus superior dimensional stability. They are broadly similar in their moulding characteristics to the phenolics.

The tables which follow, and which are reproduced unaltered from Mr. Bennitt's paper, show most clearly the properties of this range of compounds, and enable direct comparison to be made with phenolics, ureas and melamines.

Table 1 compares powder and moulding properties of electrical grade alkyd phenolic and melamine powders. No points of major significance emerge here, but in table 2 can be seen a similar comparison of materials in the moulded state. Here it will be seen that electrical grade alkyds compare very satisfactorily, from the all-round standpoint, with both phenolics and melamine, with a slight lead in favour of the alkyds.

In Table 3, rather more detailed figures are given to enable a direct comparison to be made between reinforced and general purpose alkyds themselves. Reinforcement significantly affects only bulk factor, impact and tensile strengths.

Table 4 is similar to Table 1, except that it deals with decorative

TABLE 6*

COMPRESSION MOULDING CONDITIONS FOR ELECTRICAL GRADE ALKYDS

	Standard cure		Fast cure		
	Granular	Reinforced	Low pressure	Granular	Reinforced
Recommended temperature (° C.)	160–165	160–165	140–165	140–165	140–165
Pressure (lb./sq. in.)	2,000–4,500	2,000–7,000	200–600	800–4,500	1,200–4,500
Preheating	Recommended	Recommended	Not recommended	Not recommended	Not recommended
Press closing time	Not critical	Not critical	Preferably less than 5 sec.	Preferably less than 5 sec.	Preferably less than 10 sec.
Breathing	Unnecessary	Sometimes advisable	Not practicable	Not practicable	Not practicable
Type of mould	Most types suitable	Ample headroom required	Fully positive moulds not recommended	Fully positive moulds not recommended	Ample headroom required. Fully positive moulds not recommended

TABLE 4*

POWDER PROPERTIES AND MOULDING PRC PERTIES OF DECORATIVE GRADE ALKYDS AND AMINOPLASTICS

Property	Pulp-filled		
	Alkyd	Urea	Melamine
POWDER—			
Shelf life	Good	Fair	Fair
Pelleting properties	Poor	Good	Fair
Bulk factor	3.5–5.0	2.0–3.0	2.5–4.5
MOULDING—			
Speed of cure	Similar to G.P. phenolic	Slightly faster than alkyd	Slightly faster than alkyd
Moulding versatility	Good	Fair	Fair
Rigidity on ejection	Fair–Good	Good	Good
Hot strength	Good	Fair	Good
Resistance to cracking round inserts	Good	Fair	Fair

grades of alkyd, urea and melamine. Here the alkyds, on a general comparison, show superior all-round properties. Similarly, Table 5 compares moulded properties.

In Table 6 conditions for compression moulding alkyds are given. These are especially valuable for their concise recommendations.

The economics of using the fast-moulding alkyds were con-

TABLE 5*

MOULDED PROPERTIES OF DECORATIVE GRADE ALKYDS AND AMINOPLASTICS

Property	Pulp-filled		
	Alkyd	Urea	Melamine
Colour possibilities	Good	Unlimited	Unlimited
MECHANICAL—			
Specific gravity	1.35–1.40	1.5–1.6	1.5–1.6
Impact strength (ft. lb.)	0 15–0.25	0.2–0.3	0.15–0.25
Tensile strength (lb./sq. in.)	6,000–8,000	8,000–11,000	8,000–11,000
ELECTRICAL—			
Track resistance	Good	Good	Good
Power factor at 800 c/s (%)	2–5	4–8	4–8
Electric strength at 90° C. (v./mil.)	250–350	30–150	50–100
Surface resistivity after immersion (ohms)	10^{9}–10^{10}	10^{11}–10^{13}	10^{11}–10^{12}
STABILITY—			
Water absorption (mg.)	150–250	150–500	50–150
Shrinkage after 14 days at 100° C. (in./in.)	0.002–0.005	0.015–0.025	0.015–0.025

sidered by Mr. Bennitt in some detail. Two instances were given, and these are shown in Table 7. The calculations here were based on a phenolic powder at 1s. 6d. lb. and a fast curing alkyd at 3s. lb. Corrections for specific gravity bring the actual cost of the alkyd replacing the phenolic to 4s. 6d. lb.

TABLE 7*

GREATEST WEIGHT, W, OF PHENOLIC GENERAL PURPOSE MATERIAL MOULDED PER HOUR WHICH CAN BE REPLACED BY FAST CURING ALKYD WITH SAVING IN COST UNDER SPECIFIED CONDITIONS

CONDITIONS A

Press open time 10 sec. Phenolic cure 80 sec. Alkyd cure 10 sec. (Conditions more favourable to alkyd than usually occurs in practice.)

	10s.	£1	£2
Press hourly rating			
W. pounds moulded per hour	2.6	5.2	10.4
Corresponding weight moulded per lift. Ounce	1.0	2.1	4.2

CONDITIONS B

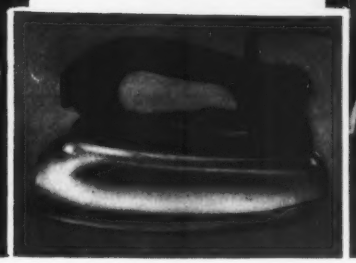
Press open time 40 sec. Phenolic cure 60 sec. Alkyd cure 20 sec. (Conditions which may reasonably be looked for in practice.)

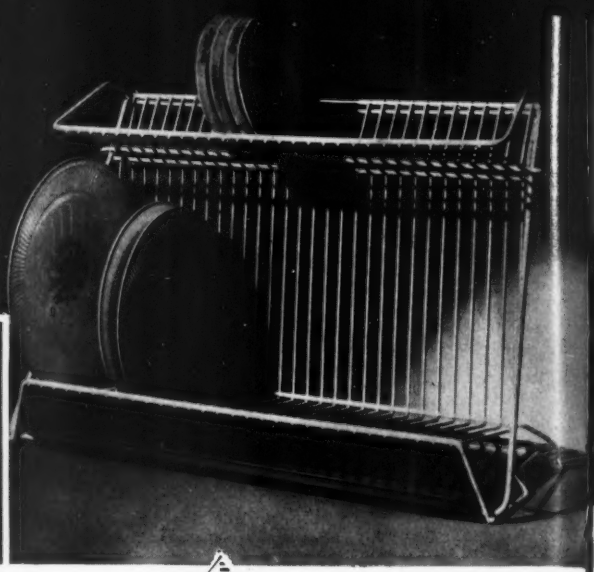
	10s.	£1	£2
Press hourly rating			
W. pounds moulded per hour	1.3	2.6	5.3
Corresponding weight moulded per lift. Ounce	0.6	1.2	2.4

* Tables reproduced from Mr. Bennitt's paper.

(Left) Tea service and mug moulded in melamine by Brookes and Adams Ltd. and designed by R. E. Brookes.

(Below) Electric steam and dry iron produced by Morphy-Richards Ltd. with moulded phenolic handle.



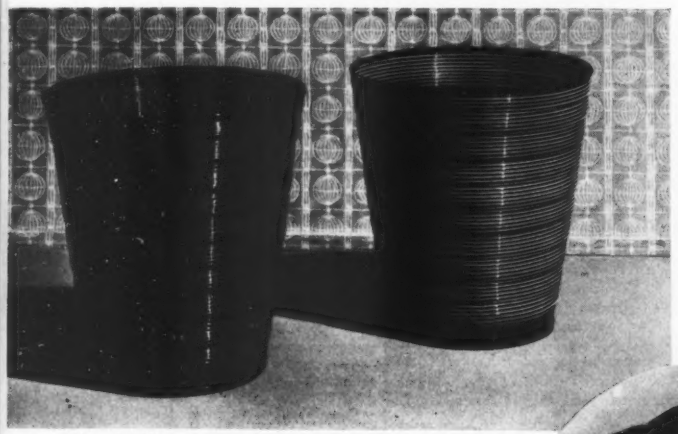


PLASTICS IN THE SERVICE OF MAN

65. Plastics at the Design Centre

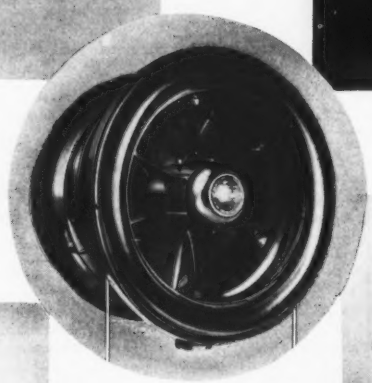
A list of trade-marks and companies mentioned in this review, with full names and addresses, appears on page 132

(Above) Plate draining rack in steel covered with p.v.c. made by Rudic Products Ltd. and designed by R. N. Keeble.



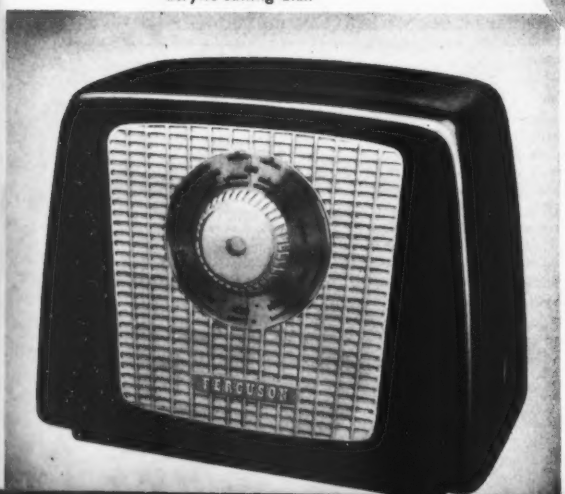
(Above) Waste paper baskets made from spun extruded acetate by Rotaflex (Great Britain) Ltd.

(Above) Set of household mixing bowls moulded from Beetle melamine by Halex Ltd.

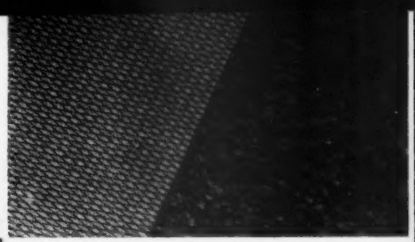


(Above) Vent-Axia reversible air conditioning fan with moulded phenolic case.

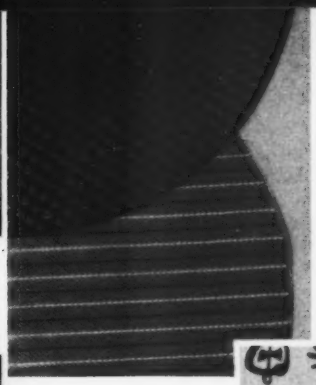
(Below) Ferguson radio receiver, model 352U with moulded phenolic cabinet and acrylic tuning dial.



(Right) Chair moulded in glass fibre reinforced polyester resin with metal legs and polyurethane cushion. Designed and made by Adrion Duckworth.

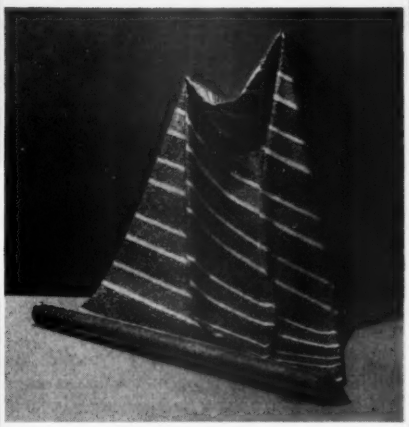


(Above) P.v.c. coated fabrics produced by Imperial Chemical Industries Ltd.



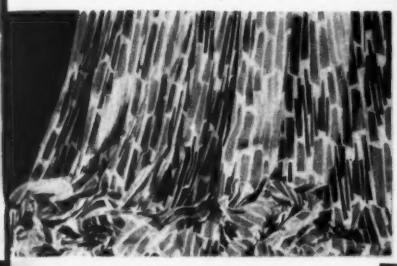
(Left) Tygan woven polyvinylidene yarn, TS9022 and TS9012.

(Above) Fabric supported p.v.c., Stafford, produced by Arlington Plastics Development Ltd.

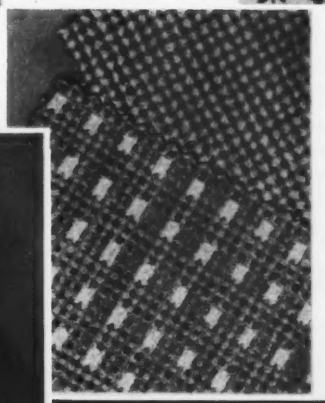


(Above) Printed p.v.c. fabric of the Folkweave pattern produced by Greenwich Plastics Ltd.

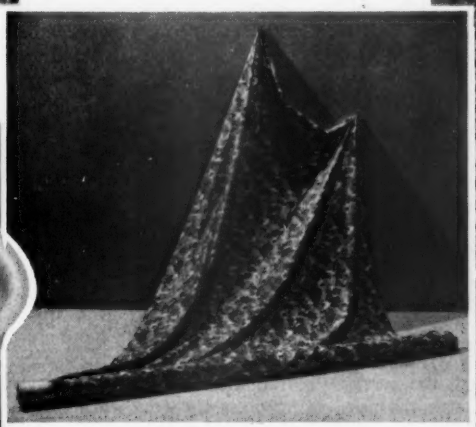
(Right) Rydura p.v.c. coated printed cotton, Innsigns, by Ryjack Productions Ltd.



(Above) Printed p.v.c. sheeting 22709 produced by Storey Bros.

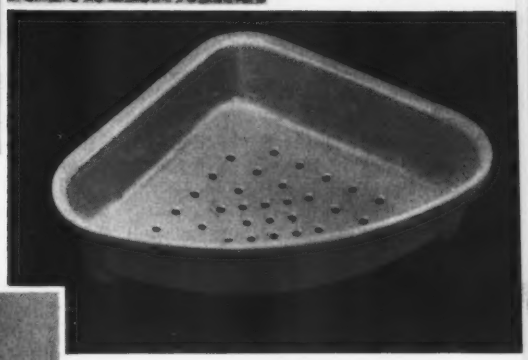


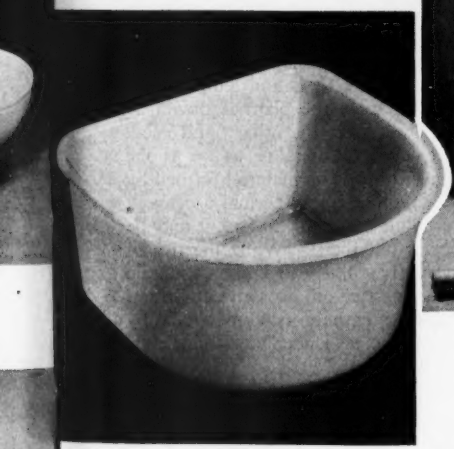
(Left) Llonide, fabric supported p.v.c. in contemporary designs.



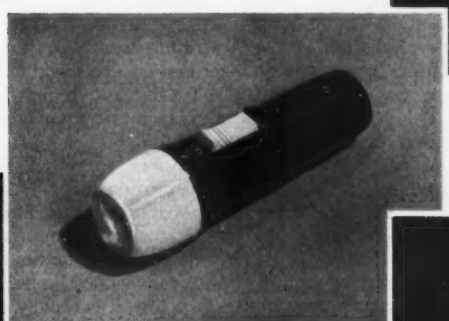
(Above) Printed p.v.c. Overcheck produced by B.X. Plastics Ltd.

(Below) Sink strainer moulded in melamine by N.B. Mouldings Ltd.



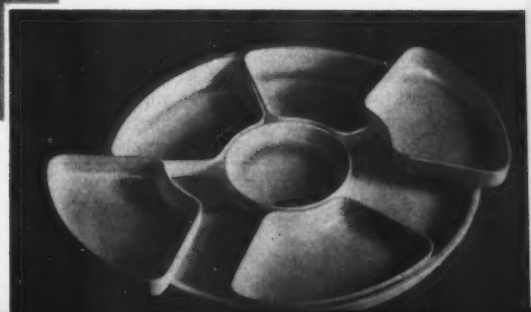


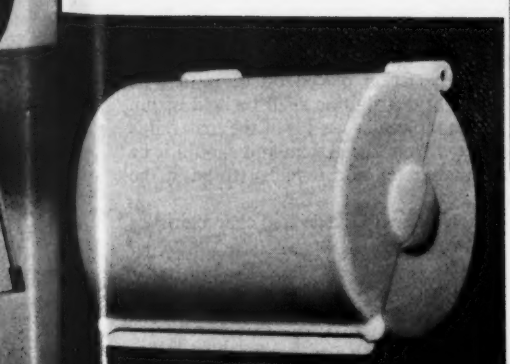
(Above) E. K. Cole D-shaped polythene plastabowl.



(Above) Bijou torch moulded by G.E.C. in polystyrene and with a polystyrene lens.

(Below) Formed acrylic hors d'oeuvres set by Thermo-Plastics Ltd.





(Left) Toilet roll holder moulded in urea by Brookes and Adams Ltd.

Radiation in the Plastics Industry

By R. ROBERTS, M.Sc., Ph.D.*

Recent announcements by leading companies to the effect that radiation facilities have been installed in their laboratories lends special emphasis to the following article which discusses the complete field.

IN the past only small radioactive sources have been available. Before the war the total world supply of radium was only of the order of a few hundred curies and was used almost entirely for radiotherapy. Now as a result of the programme for the generation of power from nuclear energy there is the prospect of very large supplies of radioactive material. At the moment radioisotopes for experimental use are being produced in ever-increasing quantities mainly by the bombardment of inactive material with neutrons. For example cobalt-60, used to provide gamma rays, is produced by the irradiation of cobalt-59 with neutrons. The only practicable source of neutrons with which to effect this change is the pile and it is immediately obvious that there must be a limit to isotopes produced in this way since neutrons absorbed in the activation process are not available for sustaining the chain reaction on which the pile depends. Furthermore, the neutron could alternatively be captured by a nucleus of uranium-238, forming plutonium which is an essential fuel for the fast and breeder reactors. Therefore if very large amounts of radiation are to be used for industrial processing, an entirely different source of radioactivity must be sought. Fortunately, the nuclear power programme will provide vast amounts of radioactivity in the form of the fission products. These fission products are simply the fragments which are left when a uranium atom undergoes fission and they consist of a group of radioisotopes within the atomic weight range of 72 to 162, with half lives ranging from a few seconds to approximately 30 years.

The power programme envisages by 1965 the generation of 2,000 megawatts of electricity from nuclear power. Estimates of the overall efficiency of the power stations vary but a figure of 20% can be assumed. (Estimates indicate that it may be higher than this.) A nuclear power capacity of 10,000 megawatts must therefore be provided and this will involve each year, the consumption of 3.5 tons of uranium-235. Although the energy liberated in the fission of a uranium-235 nucleus is large, the mass equivalent to this energy is small and therefore the estimated production of fission products in 1965 will be 3.5 tons. It can be shown that this quantity of fission products is equivalent to a steady source of a thousand million curies. By 1975 it is anticipated that the quantity of radiation available each year will have increased by a factor of five. Industrial processing using radiation therefore becomes feasible.

DEFINITIONS

CURIE: Unit denoting the activity of radio-active substances. Equals the activity of one gramme of radium.

GAMMA RAYS: Penetrating radiation emitted by some radio-active materials as they decay.

ISOTOPES: Atoms of the same element which are identical in their chemical behaviour but which have different atomic weights and also different nuclear properties.

Before examining some potential uses for radiation in the plastics industry, it is as well to consider for a moment what happens when radiation interacts with molecules. In general when radiation is absorbed by a molecule either ionization or excitation takes place. The ions formed may recombine giving again an excited molecule, that is, a molecule in a high energy state. This molecule disrupts usually giving free radicals. Radiation therefore can act as a free radical catalyst in polymerization processes but it does not, in general, act as an ionic catalyst.

This ability of radiation to initiate reaction may be used in one of two ways either to carry out the polymerization process or alternatively to modify the properties of the finished polymer. A considerable amount of research has been carried out on radiation initiated polymerization and surprising differences have been found between radiation polymerization and by conventional catalysts. One of the most interesting discoveries is the ability of gamma rays to polymerize fluorine monomers. For example perfluoropropylene and perfluorobutadiene have both been polymerized. To the best of the author's knowledge this is the first observation of the polymerization of either of these two monomers. In these cases, the polymerization rate was relatively low, but in the case of 1, 1. Dihydroperfluorobutyl acrylate much higher rates were achieved. This material, when polymerized, is, of course, F.B.A. rubber.

Solid State Polymerization

Another interesting phenomenon is the discovery that solid state polymerization can be initiated by radiation. This was first obtained using acrylamide. This substance shows little tendency to polymerize thermally at temperatures below its melting point which is approximately 80° C. Using radiation, polymerization can be effected at temperatures as low as −15° C. At these low temperatures, the radicals which are produced by the radiation are frozen in and, on warming, violent polymerization takes place. The polymerization of tetraethylene glycol dimethacrylate has been carried out at a temperature of −55° C., probably the lowest temperature at which a free radical polymerization has been observed. There is obviously much scope for a considerable amount of work along these lines and it would be very interesting to investigate polymerizations of monomers such as styrene at temperatures well below 0° C. As the temperature of polymerization is reduced, branching reactions become less important and the polymer obtained will be much more crystalline. An example of this is the polymerization of ethylene. The only commercial process, until recently, has operated at very high pressures and temperatures of the order of 200° C. In this case, the plant is obviously expensive and difficult to maintain. On the other hand using radiation, ethylene can be polymerized at pressures as low as one atmosphere and at room temperature. The material formed by this process differs from that obtained in the thermal process in that it is a tougher, more crystalline material. In fact, it may be very similar to the new Ziegler polythene. While the use of radiation to polymerize ethylene is unlikely to be an economic process, the work which has been carried out does give an insight into the possibility of producing entirely new materials by carrying out the polymerization process under conditions very different from those normally used.

Workers at the Brookhaven National Laboratory have shown that emulsion polymerization can be very easily carried out using radiation. In common with the conventional catalyst process, the radiation initiated polymerization of styrene is very much faster in emulsion than in the bulk phase. There is, however, reason to believe that the hydrogen and hydroxyl radicals which are the most probable initiators of the radiation initiated polymerization are much more efficient than radicals from the added catalyst.

Some American workers have been studying the polymerization of N. vinyl pyrollidone. This substance when polymerized is used as a blood plasma substitute and as such, by far the most important specification placed on it, is that its viscosity and molecular weight distribution shall be held within closely defined limits. If the molecular weight of the material is too low, it is rapidly excreted from the system and should it be too high, the material is unexcreted and remains stored in the reticuloendothelial system.

It has been found that polymer with the desired characteristics

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can be obtained by varying the monomer concentration, gamma ray intensity and solvent composition. In addition, fractionation data indicated that the molecular weight distribution of the radiation produced polymer was better than that obtained with catalyst produced material, in that the distribution was much sharper and therefore more of the polymer lay within the specification.

An interesting recent discovery is the carrying out of graft polymerization by using radiation. Work carried out by Chapiro at the Radium Institute in Paris has shown that graft polymerization can be achieved by two processes. The first method is by the irradiation of polyethylene in air, thereby forming a number of unstable peroxide bonds. If now the irradiated polyethylene is heated in the presence of a monomer such as acrylonitrile, the peroxide bonds are disrupted giving free radicals which act as initiators for the polymerization of the acrylonitrile monomer. One curious observation has been made if the irradiated polymer is in a definite geometrical form, as for example, in the form of a tube, film or fibre, this geometrical form is preserved during the graft polymerization. Effectively a homogeneous expansion of the material takes place. Using this technique a graft copolymer containing acrylonitrile in an amount over 43 times greater in weight than the original irradiated polyethylene, has been obtained. Similar effects have been obtained with polyvinyl chloride and graft copolymers containing 20% of acrylonitrile have been made. Polyvinyl chloride, treated in this way, has an appreciably greater heat resistance and it may well be that such material could be used for hot water pipes, etc.

The second method consists of the irradiation of a mixture of polymer and monomer. In this case fracture of the main polymer chains takes place giving free radicals which can initiate the polymerization of the monomer. In using this method, it is obviously preferable for the monomer to be more stable than the polymer. It would for example, be extremely interesting to study the product obtained from the effect of polymerization on a mixture of methyl methacrylate and polystyrene.

Effect of Radiation

Turning to the effect of radiation on polymerized materials, it has been realised for some time that in general, the properties of plastics are not improved by radiation. Most of them are decomposed when irradiated giving lower tensile strengths and other undesirable qualities. One of the exceptions is polyethylene, which undergoes cross-linking on irradiation. After irradiation, the material no longer melts on heating, it merely softens, the degree of softening depending on the irradiation dose. Care must be taken in using irradiated polythene since, in addition to cross-linking, loss of hydrogen takes place from the main chain. The material is therefore very susceptible to oxidation and to overcome this, antioxidants must be added.

With the advent of the new power programme, there is considerable interest in finding plastics which are stable towards radiation. It is very difficult to avoid the use of insulating materials within a reactor and provided that they are stable enough plastics are ideal since the atoms of which they are composed are not, in general, activated in the pile. The removal and replacement of these materials is therefore rendered much easier since after irradiation in the pile, they are not radioactive. As might be expected the plastics which are resistant to radiation are those which are fully cross-linked and which contain a large number of aromatic rings. It has been found as a general phenomenon that aromatic compounds are much more stable towards radiation than aliphatic compounds. For example, a radiation dose greater than 3×10^{10} rad is required to decrease the tensile strength of polystyrene by 50% whereas the tensile strength of polymethylmethacrylate is reduced by 50% after a dose of only 5×10^{7} rad. Among the most stable materials are asbestos filled-phenolics and furane resins.

Elastomers have proved of much greater interest than plastics. Just as polyethylene can be cross-linked by radiation, it is possible to cross-link most elastomers. This process is akin to vulcanization except that in the case of radiation the polymer molecules are vulcanized by the formation of the C-C bond, instead of the -S-S- bond as used in conventional sulphur vulcanization. In general, the results obtained with natural rubber indicate that with doses of the order of 10^{7} roentgens vulcanization giving an elastomer with properties very similar to the sulphur vulcanized material is obtained. One major advantage of radiation vulcanization when compared with sulphur is that the vulcanizing agent, the radiation, is not present in the finished product. Since at least part of the hardening which takes place when rubber is heated to high temperatures may be due to further chemical vulcanization by residual sulphur, it is reasonable to suppose that rubber vulcanized in this way would have superior high temperature properties. This supposition has been established in practice. Certain acrylate rubbers after radiation vulcanization exhibited marked superiority in their high temperature performance. One experimental acrylate elastomer showed embrittlement after eight hours at 350° F. in oil when chemically vulcanized, whereas the same degree of embrittlement was achieved only after 36 hours when radiation was used. Appreciably lower values for compression set at 250° F. were obtained when Buna N elastomers were vulcanized with radiation instead of sulphur. It may be observed that the acrylate rubber vulcanized by radiation is one which is difficult to vulcanize chemically and it may well be that the best use for radiation in this field is in the vulcanization of elastomers which are vulcanizable only with difficulty by using conventional techniques. Examples of this are the fluorine and silicone elastomers. As we have seen already perfluorobutylacrylate rubber has been made using radiation. The solubility of this product in fluorine containing solvents is appreciably lower than that obtained by chemical processing.

This advantage of the lack of the vulcanizing agent in the finished material is also present in radiation initiated polymerization. In this case the final polymer does not contain any residual catalyst molecules and it may be that in some cases better high temperature properties will result since there is definite evidence that the initial reaction in the depolymerization of polymers may be the splitting off of the catalyst molecule on the end of the chain.

We have seen that polymerizations can be carried out and polymer properties modified using radiation. Generally the dose required for polymerization is of the order of 10^{6} roentgens whereas that required for the modification of the properties of polymers is of the order of $10^{7}/10^{8}$ roentgens, for example the modification in the properties of polyethylene requires a dose of 5×10^{7} roentgens. It is obvious therefore that the cost of carrying out radiation initiated polymerization will be less than that of polymer modification. Estimates for the probable cost of using radiation indicates that a dose of 10^{6} roentgens can be delivered at a cost of 1d./lb. It is immediately obvious that the modification of finished polymers using radiation will be acceptable only, if the final material has unique properties or where the raw material cost is a small part of the cost of the finished article. The search therefore for applications of radiation in the plastics field should be directed towards the discovery and development of new materials. Of greatest interest at the moment, are the high temperature plastics since the ever-increasing speeds of modern aircraft is leading to a demand for materials having much improved high temperature properties. Ample radiation is available, and from a million curies of activity it will be possible to produce at least 10,000 tons of polymer each year. As we have seen, by 1965 over 1,000 times this quantity of radiation will be available.

Considerable opportunities await British industry in the use of radiation. The first large supplies of radioactivity will not be available for two to three years but sufficient material is available now for large scale research to be carried out. The Atomic Energy Authority has formed at Harwell, a new group, The Technological Irradiation Group, with the object of helping British industry to take advantage of these new developments in the use of radiation for industrial processing.

The Surface Degradation of Perspex by Ultrasonic Radiation

By N. H. LANGTON,* M.Sc., Ph.D., A.M.Brit.I.R.E., A.Inst.P.

Introduction

THE degradation of certain high polymers when exposed to ultrasonic irradiation seems to be a fairly well established experimental fact. Degradation has been shown to occur when solutions of polystyrene or polymethyl methacrylate are irradiated by ultrasonics of frequencies in the range 25 kilocycles up to about 1 megacycle. Most of the work seems to have been done using frequencies below 1 Mc/s and at fairly low power inputs. The degradation which is observed appears to be a breaking down of the long molecules into particles of lower molecular weight. This change of molecular weight is investigated by measuring the viscosities of the solutions before and after irradiation using a capillary tube type of viscometer. As the length of time the polymer solution is irradiated increases, so does the number of molecules broken down. After several hours irradiation at 0.5 Mc/s frequency, the molecular weight may be less than 1,000. The effect, however, reaches saturation after long periods of irradiation, and no further degradation occurs, the average molecular weight becoming constant at some value around 800. There is considerable doubt as to how much of this degradation is permanent, and the conditions under which the irradiation takes place probably need to be more carefully specified. Research upon this degradation is proceeding at the National College, using higher frequencies and powers.

As a corollary to this work, it was decided recently to begin a study of the degradation of the surfaces of solid high polymers when exposed to ultrasonic radiation of 1 Mc/s frequency. The surface changes which occurred were observed using an electron microscope, and some of the results obtained in this preliminary work are shown here.

Apparatus

The ultrasonic radiation was obtained from a Mullard 600 watt high frequency generator feeding into a quartz crystal transducer cut to vibrate at 1 Mc/s. To prevent fracturing of the rather fragile quartz crystal, it must be operated under water, and is therefore encased in a watertight metal box having a circular aperture 4.3 cm. diameter through which the ultrasonic energy is radiated. The ultrasonic power output from the transducer can be varied by altering the voltage at which the transducer operates, and up to about 300 watts of ultrasonic power can be obtained.

The transducer was placed at one end of a glass tank holding about 10 gallons of water. The pieces of Perspex which were to be exposed to the radiation were held in a clamp 10 cm. from the face of the quartz. Since the ultrasonic beam from the transducer is almost parallel, having an angle of spread of only about 4 degrees, any small error in distance from the face of the transducer would have little effect upon the power received by the front face of the Perspex block. The Perspex blocks used were cut from $\frac{1}{8}$in. sheet obtained commercially, and were all about 3 cm. by 2 cm. side lengths. Thus the whole of the rectangular surface of the Perspex would be in the ultrasonic beam. The blocks were clamped with their long sides vertical, and their front and back surfaces were parallel to the transducer face. A large watch glass was held at an angle behind the Perspex block, as shown in Fig. 1, so that any ultrasonic energy transmitted by the block would be reflected up to the water surface where it would be dissipated, and thus would not be reflected from the rear surface of the tank and back to the Perspex. In some cases a small vertical hole was drilled in the block parallel to the long side and reaching about three-quarters of the way down. This hole could hold a needle thermocouple so that the temperature changes in the block could be observed.

* National College of Rubber Technology.

Results

In all the cases mentioned here, the transducer voltage was 2,000, so that the ultrasonic power output from the transducer was 72 watts, assuming that the transducer was 90% efficient. This power was transmitted in an almost parallel beam of diameter 4.3 cm., so that the power output per unit area was 4.97 watts/cm^2. Thus, ignoring the small attenuation caused by the water, the energy incident upon the Perspex blocks could be calculated from the area of the front face. In a typical example, the front face area of the Perspex block was 5.84 cm.^{2}, hence the total incident energy was 29.0 Joules/sec., or 6.94 calories/sec. Not all of this energy was absorbed by the Perspex, but the amount that was can be calculated from thermal data derived in subsidiary experiments, as mentioned later.

The effect of this ultrasonic energy on the surface of the Perspex was observed by following the changes using a Phillips 100 kV electron microscope, of resolution 25 Angstroms. The technique of observing surfaces using electron microscopes is to make a mould, or replica, of the surface, which is thin enough to allow the transmission of the electron beam. In the present instance this was done by placing the Perspex blocks in a vacuum, and spraying metal atoms over the surface until a film a few hundred Angstroms thick was obtained. This film is then peeled off in small portions, suitably mounted, and examined in the microscope. Each replica thus obtained is about 2 mm. square, and it is therefore possible to examine small areas of the Perspex surface in turn for any changes.

Normal unirradiated Perspex was first examined. The replica photograph is shown in Fig. 2, the magnification is 21,000, the distance between the two vertical fiducial marks at the top of the photograph being 1μ, or 0.0001 cm. The surface is seen to be relatively smooth, the small darker irregularities on the photograph representing pits on the original Perspex surface. The larger of these areas are pits about 30 millions of a cm. across on the actual surface, and probably a few millionths of a cm. deep, so that macroscopically such a surface would appear quite smooth.

Fig. 3 shows the Perspex surface after 1 minute irradiation, the magnification now being 7,500. It can be seen that the surface is fairly uniformly covered with small pits, and is typical of the erosion caused by ultrasonic cavitation. This cavitation is produced by the formation in the water at the irradiated surface of numerous small bubbles, each of which is a centre of high pressure many times that of the pressure in the ultrasonic beam itself. These cavitation bubbles, which may be vapour filled or quite empty, rapidly erode the surface being irradiated, even in the case of metals.

After two minutes irradiation this cavitation erosion is more marked, but there can also be seen the beginning of a new type of structure on the surface, which is not apparent after 1.5 minutes irradiation. These photographs are not shown here. It should be mentioned that up to this point visual examination of the irradiated surface with the naked eye shows no marked change. If the Perspex is examined in polarized light, however, it has now become birefringent, whereas normal unstressed Perspex is not.

Fig. 4 shows the Perspex surface after 2.5 minutes irradiation when the new structure is well developed. The magnification is 19,500. We see that the surface is covered with an interlocking mass of needle shaped structures which have an almost crystalline appearance. These structures are over 1μ in length and orientated at random. At the same time the Perspex surface can be seen to have developed a small blister with a central crack. These acicular structures are most apparent in this region. If we examine the surface away from the blister, there is mainly the normal cavitation erosion. Thus it appears that these new

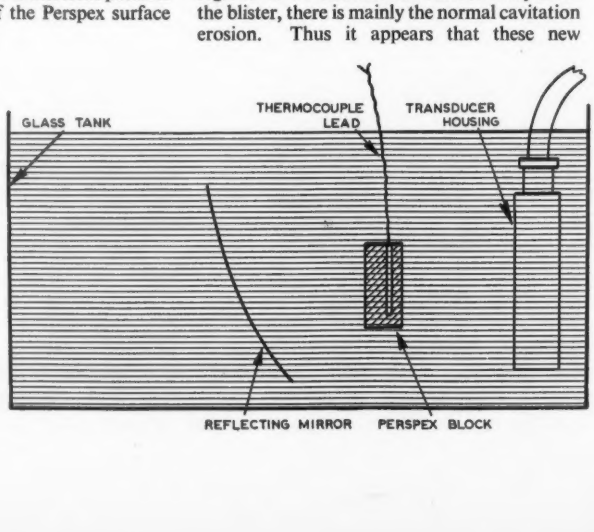


Fig. 1. The experimental arrangement, enclosed within a glass tank of 10 gallons capacity.

structures are associated with the formation of a blister on the Perspex surface. Since blistering is generally associated with heating, it was thought that the effect might be purely thermal, but further investigation indicated that this was probably not so.

Fig. 5 shows the surface replica for 5 minutes irradiation. It can be seen that the acicular structure has now almost entirely disappeared and a certain amount of cavitation pitting is once more apparent. The magnification in this case is 20,000. The fine mesh lines in the photograph background should be ignored as this is an artifact caused by the metal of the replica itself.

Fig. 6 shows the Perspex surface after 10 minutes irradiation, the magnification being 17,000. The general appearance is the same as Fig. 5, but now the irregularities are larger and more definite and there is very little left of the needle-like appearance evident on Fig. 4.

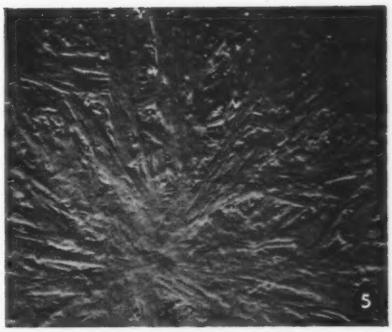
Fig. 7 shows the surface after 15 minutes irradiation the magnification being 19,000. The appearance is now very different from any of the previous photographs, the surface being deeply pitted and very irregular. All traces of the acicular structure have disappeared, and there is no sign of the usual type of cavitation pitting seen before.

Fig. 8 shows the surface replica obtained after 20 minutes irradiation, the magnification being 20,000. The extra five minutes irradiation has produced another remarkable surface change. The deep erosion of the previous case has gone, and in its place we see a return to the needle-like type of structure seen previously after 2.5 minutes irradiation. A comparison of Figs. 8 and 4 show that now the needle-like structures are much less strongly marked and the surface appears smoother than before. It may be, however, that here we have either the beginning or the end of the formation of the structure shown in Fig. 4, and this can no doubt be verified by further investigation.

Finally, Fig. 9 shows the surface after 30 minutes irradiation, the magnification being 10,000. The surface again shows a great difference from that of Fig. 8. There is no sign of the acicular appearance of the latter, the surface now appears deeply eroded in an irregular manner. The general appearance is rather similar to that shown in Fig. 7.

Discussion

No attempt will be made here to explain the changes observed, because the effects are very complex and could obviously be caused by many factors, and much further investigation is required. It seems, however, that the changes may be cyclic, repeating as the irradiation is continued. It is obviously necessary to determine how much of the changes are due to the effect of the ultrasonics and how much are caused by the heating of the Perspex surface by the absorption of the sound energy. To obtain some indication of this, the heating of the Perspex blocks were observed by means of a thermocouple inserted into the hole mentioned previously. It was found that the temperature of the block rose smoothly until a steady temperature of about 140° C. was attained after about 6 minutes. After 2.5 minutes, which was when the needle-like appearance was first seen, the temperature had risen to about 120° C. During the first few experiments on the measurement of temperature, the thermocouple was placed about 1 mm. from the front face of the block, and it was thought that these readings might be too low, there being the possibility of a high temperature layer at the irradiated surface. Measurements of temperature rise were therefore taken with the thermocouple hole drilled very close to the front surface. In such cases, when the thermocouple was only about 0.2 mm. from the irradiated surface, there was no significant increase in the rate of temperature rise. This is probably because the front face of the block is more efficiently cooled than the other surfaces. The block is continuously cooled by the surrounding water, which is always at room temperature, the mass of water being too large to exhibit any heating due to ultrasonic absorption. During the experiments room temperature was always about 20° C. The water in the vicinity of the front face, however, is continuously disturbed by the sound vibrations and the cavitation at the Perspex surface, and this disturbance helps to cause more efficient cooling than over the rest



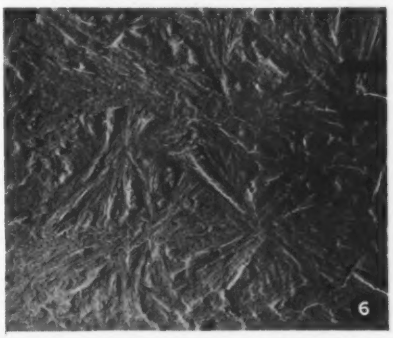
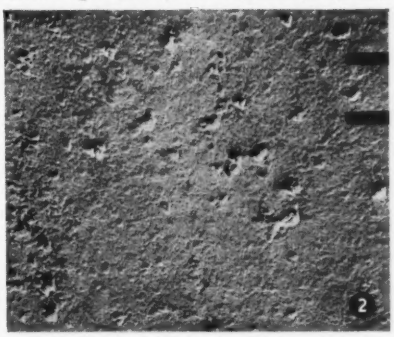
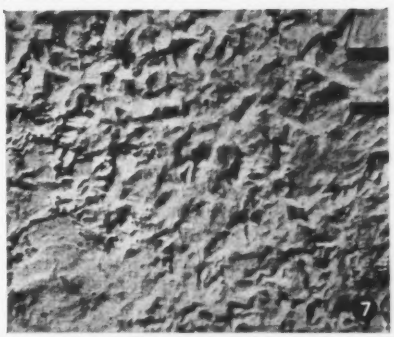
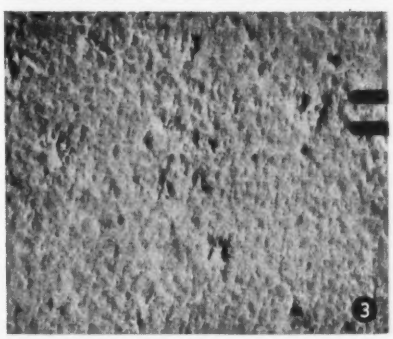
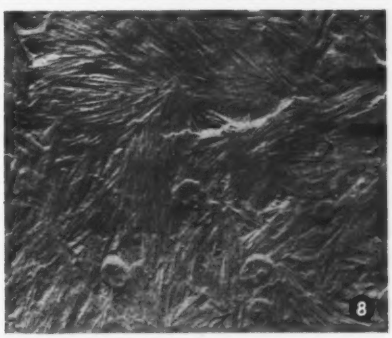


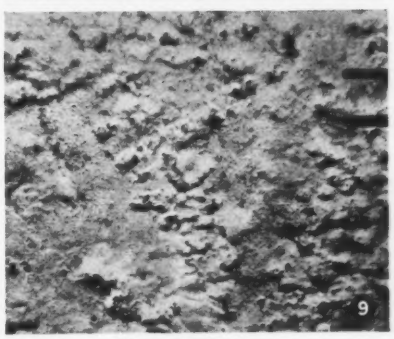
Fig. 2. Normal unirradiated Perspex surface. Magnification 21,000. Fig. 3. Surface after 1 minute irradiation. Mag. 7,500. Fig. 4. Surface after 2.5 minutes irradiation. Mag. 19,500. Fig. 5. Surface after 5 minutes irradiation. Mag. 20,000. Fig. 6. Surface after 10 minutes irradiation. Mag. 17,000. Fig. 7. Surface after 15 minutes irradiation. Mag. 19,000. Fig. 8. Surface after 20 minutes irradiation. Mag. 20,000. Fig. 9. Surface after 30 minutes irradiation. Mag. 10,000. (All Minalpha alloy replicas.)











of the surface of the block. To test this, a series of temperature reading were taken with the thermocouple placed in a hole near the back surface of the block, so that there was about 0.7 mm. of material between it and the irradiated surface. It was now found that the temperature rose rather more quickly than before. The cooling curves obtained in this case were identical with those obtained when the thermocouple was near the front surface. Since the cooling curves are obtained when the ultrasonic radiation is absent, the conditions of cooling are always the same, so that it appears that the lower rate of heating found near the front surface of the block during irradiation was due to more efficient cooling. We can therefore conclude that the temperatures recorded on the thermocouple during irradiation are likely to be a little higher than the real temperature of the irradiated surface, and there is probably no high temperature layer at the front surface that could account for the phenomena observed. A typical heating curve is shown in Fig. 10.

By increasing the transducer voltage it was possible to cause the temperature of the blocks to rise above 150° C. On switching off, it was possible to obtain a cooling curve, such as that shown in Fig. 10. The slope of this curve at the steady temperature reached by the block during irradiation gives a rough value of the rate of loss of heat at this temperature. The value is only approximate, since the cooling conditions with the sound switched off are not

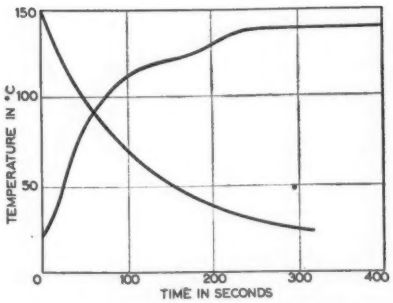


Fig. 10. Heating and cooling curves for Perspex block.

the same as those during irradiation, and also the physical properties of the Perspex will be different. The rate of loss of heat is equal to the rate at which the ultrasonic energy was being absorbed at the steady temperature approximately. Since it is possible to calculate the incident ultrasonic energy from the operating conditions of the transducer, we can therefore estimate the amount of energy actually absorbed by the Perspex. It was found that the Perspex used in these experiments absorbed about 27% of the incident energy, which means that about 1.3 watts/cm². was being absorbed, the rest of the energy being reflected or transmitted. If we assume that no ultrasonic energy was being transmitted, these figures enable an upper limiting value of the acoustic impedance of the Perspex to be calculated. The figure obtained was $1.64.10^6$ c.g.s. units, which is of the correct order for glass-like materials.

Attempts have been made to cool the Perspex during irradiation, but no reliable results have yet been obtained. If the material is heated in a flame, the surface photographs obtained are quite unlike any of those shown here, although a faint trace of the acicular structure shown in Fig. 4 was found once in a very small region.

There is little doubt that the erosion is caused by the ultrasonic cavitation, but the origin of the acicular structure may be mainly thermal, and further work is now being carried out to try to distinguish between the purely thermal phenomena and that due to ultrasonic degradation. Some of the effects may also be due to the presence in the Perspex of monomer and plasticizer. It is hoped that this work will lead to more information about the surface structure of high polymers, and attempts will be made to correlate the ultrasonic surface modifications with other physical properties of the surfaces.

Acknowledgement

The author wishes to record his gratitude to Miss M. Stephens, Senior Laboratory Assistant at the National College of Rubber Technology, who has taken all the photographs shown in this article, prepared the metal replicas of the surfaces and operated the electron microscope.

Commercial Applications of Radiation

IN the preceding pages radiation has been discussed both in general terms and in specific instances. Readers will be interested in the following notes which deal briefly with apparatus installed by two leading companies, one a plastics raw material manufacturer, Monsanto Chemicals Ltd., and the other a fabricator, Tube Investments Ltd.

THE RIDEAL LABORATORIES (MONSANTO CHEMICALS LTD.)

These laboratories were opened by Professor Sir Eric Rideal on April 17 and constitute a notable addition to research facilities for Britain's chemical industry.

The radiation laboratory has been designed primarily to permit study of the effect of γ-radiation on materials such as plastics and also to use the radiation for promoting chemical reactions. In addition, the facilities should permit the use of small β-sources for similar types of studies.

The gas chromatograph in the Rideal Laboratories.

The initial design provides for work with two separate 100 curie cobalt 60 sources, but small modifications should enable studies to be made with up to 500 curies of this isotope and 1,000 curies of caesium 137.

Two distinct types of study are to be made, although in a given experiment both effects are often present together and have to be separated or allowed for.

(*a*) It is now well known that γ-radiation can bring about interesting and sometimes valuable changes in the properties of materials. These changes have been particularly studied in the field of plastics, and as new plastic materials come forward, they in turn will be examined under the influence of radiation. The effects produced indicate the value of the sample as a structural material in high intensity radiation fields.

(*b*) Radiation can often be used to replace heat, light or catalysts in promoting the chemical reactions which are the basis of a chemical industry's operations.

In the present state of knowledge in the field of radiation chemistry, it is felt desirable to examine as wide a range of reactions as possible, for it is not yet possible to predict just exactly what reactions may occur, nor what properties a given product may have. In particular, the yield of reaction product per unit of radiation absorbed is still a factor which can only be determined by experiment.

HINXTON HALL (TUBE INVESTMENTS LTD.)

The radiation sources available at Hinxton comprise the following:—

1. A Van de Graaff generator capable of producing a two million volt beam of radiation at high intensity. Articles for radiation are taken by a series of conveyor belts from the control room into the radiation chamber in the tower and under the beam where the electron beam is scanned across individual specimens by electro-magnetic means controlled externally by the operator. A series of external controls on the speed of the conveyor belts allows the radiation dose and time of irradiation given to each specimen to be varied at will.

A number of auxiliary devices are being designed and built to enable a variety of materials to be irradiated on a semi-continuous basis.

2. An X-ray machine operating at 250,000 volts. This produces a beam of higher penetration but has a much lower intensity.

3. An X-ray machine producing an intense beam of X-rays of up to 50,000 volts. The penetration is very low and the equipment is mainly intended for surface treatment.

4. A high intensity radioactive cobalt source giving gamma radiation (1.3 million volts) of high penetration. The design of the equipment permits variable dosage rates to be applied. The radioactive cobalt container sinks into the base when the machine is being loaded with specimens and the equipment is also arranged to provide a narrow beam of gamma radiation.

The latter three sources of radiation are intended as auxiliaries to the main two million volt accelerator.

The programme of work to be covered with the radiation equipment available includes both research and development.

In the first instance, the effect of irradiating plastic materials will be studied in detail since it has already been shown that very useful changes can be produced in a variety of materials such as polyethylene, nylon and rubber. At the same time, fundamental research into the method by which radiation interacts with material will also be undertaken.

P.V.C. Pastes—Theory and Practice

PART I. Paste Formulation.

By M. S. WELLING*

This article, the first of two, has been written in order that a complete picture is available to users of p.v.c. pastes on both constituent materials and technology of application.

Introduction

POLYVINYL chloride—p.v.c. for short—has come to the fore in Britain only during the last ten years. Production in this country has increased from 3,000 tons p.a. in 1944 to 50,000–60,000 tons p.a. during 1955, and it is estimated that by 1957 there will be capacity to make 60,000-70,000 tons of p.v.c.

Monomeric vinyl chloride was first reported by Regnault in 1835. Formation of a white powder on exposing vinyl chloride sealed in a glass tube, to sunlight, was observed a few years later and by 1872 the chemical inertness of this powder was recognized. By 1914 the addition of catalysts such as peroxides for the thermal polymerization of vinyl chloride was established.

The development of plasticized p.v.c. materials dates from 1930 when Dr. W. L. Semon of the B. F. Goodrich Co. in America first discovered that p.v.c. can be compounded with certain high-boiling esters at about 150° C. to form rubber like masses which remained homogenous after cooling down to room temperatures.

The present article is intended to cover the manufacture of p.v.c. pastes together with the theoretical and practical considerations which have to be taken into account in paste formulation. In a later article it is proposed to discuss the most important uses of p.v.c. pastes.

Development of P.V.C. Pastes

Prior to the introduction of p.v.c. pastes, the only methods of utilizing such high polymer resins involved the use of large quantities of expensive and hazardous solvents, such as acetone, methyl ethyl ketone, etc. Because of the restricted solubility of such resins, solutions necessarily had a very low solids content.

The Germans discovered, some 20 years ago, that vinyl resins of high molecular weight could be ground in organic media to form stable dispersions, provided the dispersing phase has some solvating action on the resin, but not enough to dissolve it. This phenomenon was utilized for cloth coating, some coating being done in this country in 1939. There is evidence to show that Germany was also doing work in this field at about that time.

The most significant progress in this field was the development by the Distillers Co., Ltd., of a finely divided p.v.c. resin permitting, by a simple stir-in technique, the preparation of pastes containing no volatile ingredients. This process was developed from the pilot plant scale to commercial production by the B. F. Goodrich Chemical Co. in 1947, and in 1948 the resin was produced commercially in this country by British Geon Ltd.

Vinyl pastes are dispersions of paste polymers in non-aqueous liquids which do not dissolve the resin at ordinary temperatures. After the dispersion has been applied to fabric or paper it is heated to bring about mutual solvation of resin and plasticizer, thus converting the semi-fluid coating into a tough cohesive layer.

Vinyl pastes are divided into two main categories:—

(i) Plastisols, which are 100% solids mixtures containing paste polymer and compounding ingredients dispersed in plasticizer. Layers or coatings deposited from plastisols are fused at about 170° C., the actual temperature depending on the type of plasticizer and polymer used.

(ii) Organosols, which are low viscosity mixtures of paste polymer and compounding ingredients dispersed in a mixture of plasticizer and an organic diluent, having a solids content varying between 60 and 80%. The proper balancing of dispersant (plasticizer) and diluent is essential. Excess diluent promotes flocculation whilst excess dispersant produces over-solvation.

The main advantages of using plastisols for coating fabrics in preference to organosols are that, since plastisols are entirely composed of non-volatile materials, single coats of almost unlimited weight can be applied; and the absence of inflammable solvents eliminates fire and explosion risk as well as the need for expensive solvent recovery equipment. The fact that no solvents are employed in plastisols also brings the added advantage that there can be no solvent retention in the fused film which might later have harmful effects.

P.V.C. Paste Polymers

A paste polymer is defined as a high molecular weight polymer which will form a viscous liquid on mixing with normal quantities of plasticizer at room temperature. To fulfil this condition the polymer must be able to form a paste by simple addition of just enough plasticizer to give a non-tacky film after fusion by heat. The paste must also be stable over long periods at normal temperatures, i.e., it must not gel during storage.

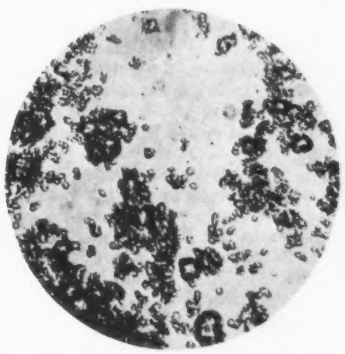
It is possible to make a paste from almost any emulsion-polymerized material, but it is preferable to use a specially manufactured paste polymer having a small particle size, i.e. 1 to 2 microns, in order to give the best possible combination of low paste viscosity, good storage life and a dry, non-tacky surface finish of the end product.

The paste making properties of a p.v.c. polymer are determined by three factors: (*a*) particle size and distribution; (*b*) polymer/plasticizer reaction on the particle surface; (*c*) chemical nature of the particle insofar as it affects solution and swelling of the particle in the plasticizer. All these factors are controlled during the manufacture, and only the first can be influenced by any after treatment, e.g. grinding.

Several advantages are gained by the partial substitution of the paste polymer by a non-paste forming resin. An example is the partial replacement of Geon 121 by Geon 202, which results in a marked change in the rheological properties as compared with pastes based on Geon 121 alone. The advantages are:—

(1) Lower paste viscosity, at equal plasticizer content.
(2) Improved paste ageing properties.
(3) Greater hardness at equal viscosity.
(4) Lower cost.

The effect of partially replacing Geon 121 by Geon 202 is that, whatever resin/plasticizer system is used, the viscosity drops to a minimum at a Geon 202 content of about 45% and



Microphotograph of Geon 121 resin (magnification x 400).

then rises again on further replacement. Another effect of this addition of a non-paste making resin is that pastes of a much lower plasticizer content can be prepared. For example, it is impossible to mix a 70/30 polymer/plasticizer paste using Geon 121

Microphotograph of Geon 202 resin (magnification x 400).

alone. However, when 20% or more of the Geon 121 is replaced by Geon 202 a workable paste can be prepared.

As far as ageing properties are concerned, these improve progressively as the Geon 202 content is increased.

The principal factor limiting the amount of Geon 202 which can replace Geon 121 in the more heavily plasticized pastes is the tendency

* British Geon Ltd.

for sedimentation to occur. This effect becomes less apparent as the plasticizer content is decreased.

Plasticizers

Plasticizers form an essential part of any vinyl compound or paste, ranking in importance with the polymer itself. The following definition has been given: "A plasticizer or softener is a substance incorporated in a material to increase its flexibility, workability, or distensibility. A plasticizer may reduce the melt viscosity, lower the temperature of a second order transition, or lower the elastic modulus of the product."

Plasticizers are of five main types: (1) Organic esters, e.g. phthalates, adipates, sebacates; (2) inorganic esters, e.g. aryl, alkyl and mixed phosphates; (3) polyethylene glycol ester and derivatives of natural unsaturated oils; (4) polymeric plasticizers, e.g. polyesters and nitrile rubbers; and (5) miscellaneous types, such as nitriles, amides, hydrocarbons, and sulphur containing derivatives.

The mechanism of plasticizer action is somewhat complex. Pure p.v.c. at room temperatures is hard because the polymer chains are held together by strongly cohesive forces in the molecule. The kinetic energy at ordinary temperatures is insufficient to separate the chains. By heating the polymer above its melting point in the presence of plasticizer, these cohesive forces are overcome and the plasticizer forces its way between the chains, keeping them apart. This condition persists on cooling to room temperature, and the resin/plasticizer combination retains its elastomeric or flexible condition.

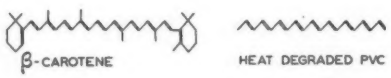
The selection of the plasticizer system is of critical importance in paste compounding. Since the plasticizer is the sole dispersing medium, it determines to a large extent the flow properties of the vinyl paste, as well as the flexibility, low temperature properties and migration characteristics of the finished product.

Both the viscosity and solvating power of plasticizers affect paste viscosity. Since the initial viscosity of a paste is directly proportional to that of the plasticizer a high degree of fluidity on the part of the latter is desirable. The solvating action of the plasticizer has a marked effect on viscosity stability. Strongly solvating plasticizers swell the vinyl resin particles in time and increase the viscosity of the paste. It is important therefore, to use plasticizers which have little or no solvating action on the resin at ordinary temperatures if the paste is to be stored for any length of time.

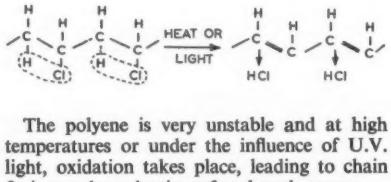
Stabilizers

When p.v.c. and its copolymers are heated above 170° C. they tend to decompose and become discoloured. Similar changes occur under the influence of light. The mechanism of the thermal degradation of vinyl chloride polymers is understood to consist of two main stages. First, hydrochloric acid splits off from the polymer, leaving an unsaturated structure. Secondly, oxidation occurs at the resulting points of unsaturation. When heat is the primary degrading influence, hydrogen chloride formation is the main process, with oxidation playing a secondary part. If U.V. light is the primary influence, the reverse is the case. These two mechanisms generally occur simultaneously regardless of whether the source of degradation is heat or light. The rate of breakdown of the resin is accelerated by traces of certain metals such as zinc and iron.

The hydrochloric acid evolved exerts a further catalytic action by promoting stepwise removal of more hydrochloric acid along the chain, resulting in a conjugated double bond system referred to as a polyene. Conjugated linear polymers are all strongly coloured—an example is carotene, the colouring matter of carrots. The structure formed by the thermal



degradation of p.v.c. has similar chromophoric properties which are responsible for the yellow, orange, red, brown and finally, black colour of degraded polymers. The reaction outlined above is catalysed by the hydrochloric acid itself.



The polyene is very unstable and at high temperatures or under the influence of U.V. light, oxidation takes place, leading to chain fission and production of carbonyl groups.

In order to prevent breakdown of vinyl polymers due to excessive heat, it is essential to add stabilizers to vinyl pastes and other vinyl compounds. Stabilizers fall into four groups: (1) Acceptors of hydrochloric acid, which absorb the acid as it is formed, thus avoiding the autocatalytic process; (2) materials which will react with and thus neutralize, the effect of the colour forming diene structure; (3) antioxidant materials which prevent any further decomposition of the unsaturated structures arising in case (2) by eliminating the available oxygen; and (4) materials which filter out U.V. light.

Compounds used as vinyl stabilizers are divided into three major categories: metallic, organo-metallic and organic. The first group is the most important. Stabilizers which can be used in the production of p.v.c. pastes are metallic "soaps," i.e. salts of metals with fatty acids. These include stearates, laurates, naphthenates, and ricinoleates of lithium and sodium, magnesium, calcium, strontium and barium, cadmium, tin and lead. Phosphates, phosphites, silicates, salts of organic acids and organo-tin compounds, are also used.

(i) Heat Stabilization. Although Geon 121 possesses excellent heat stability, the temperature range over which it can be processed may be further extended, in common with other polyvinyl chloride resins, by the incorporation of heat stabilizers.

The stabilizer most commonly employed for opaque formulations is basic lead carbonate. This stabilizer imparts excellent heat and light stability and has the added advantage of low cost. Another excellent stabilizer for Geon 121 is dibasic lead phosphite. One per cent. of either, based on the weight of the paste, is usually sufficient for most purposes though this quantity may naturally be increased if abnormally severe heat treatment is likely to be encountered during processing. Also if the paste is made with mixtures of Geon 121 and Geon 202 more stabilizer will generally be required. Calcium stearate is used when transparency is desired, the amount being of the order of 1% based on the weight of the paste. Cadmium and lead stearates, barium ricinoleate and certain tin salts are sometimes used for this purpose, and under certain conditions may be more efficient than calcium stearate. Since many stearates increase paste viscosity it is advisable not to use them in more than small quantities.

Table I shows the relative effectiveness of a number of heat stabilizers as assessed by the Congo Red Stability Test.

TABLE I
HEAT STABILIZERS FOR GEON 121 PASTE RESIN

Stabilizer	*Congo Red Min. @ 180° C.*
Dibasic lead phosphite	101
Basic lead carbonate	83
Basic lead carbonate + Salol	85
Calcium stearate	39
Barium ricinoleate	27
Lead stearate	19
Cadmium stearate	14
Control (no stabilizer)	4
Compound :	
Geon 121	60
Tritolyl phosphate ...	20
Dioctyl phthalate ...	20
Stabilizer	1

Details of the Congo Red Stability Test are as follows:—

A standard weight of the p.v.c. material is cut up and placed in a boiling tube immersed in an oil-bath at 180° C. The tube is lightly closed with a plug to which is fixed a strip of congo red test paper.

The time taken for any decomposition products of the p.v.c. to turn the test paper blue is recorded as the stability time of the material.

(ii) Light Stabilization. The most effective light stabilizers for Geon 121 are lead and cadmium stearate. The results of tests reported in Table II show that compounds containing these stabilizers are unaffected by daylight exposure to Standard 6 (B.S. 1763) whereas the unstabilized compound fades at Standard 2. Dibasic lead phosphite and calcium stearate are also fairly good light stabilizers for Geon 121 as is basic lead carbonate with a 1% addition of Salol (phenyl salicylate). It will also be seen that although compounds stabilized with barium ricinoleate fade initially at Standard 2, they are not seriously affected at Standard 6.

TABLE II
LIGHT STABILIZERS FOR GEON 121 PASTE RESIN

Stabilizer	Daylight Exposure	
	Initial Fading	Condn. at Standard 6
Dibasic lead phosphite ...	Standard 4	V. sl. fading
Basic lead carbonate ...	Standard 2	Sl. fading
Basic lead carbonate + Salol	Standard 5	V. sl. fading
Calcium stearate	Standard 5	Sl. fading
Barium ricinoleate	Standard 2	Some fading
Lead stearate	Unaffected	Unaffected
Cadmium stearate	Unaffected	Unaffected
Control (no stabilizer) ...	Standard 2	Darkening

Certain plasticizers have a pronounced effect on the heat and light stability as well as weathering properties of pastes, the final effect depending on the chemical structure of the plasticizer and the ease with which it is oxidized. Some of these plasticizers are susceptible to oxidation and hydrolysis, resulting in breakdown into undesirable degradation products. Vinyl stabilizers therefore—besides preventing the degradation of the

polymer—should also prevent plasticizer breakdown, or at least not contribute to such breakdown.

Fillers

The primary function of fillers in paste compounding is cost reduction. Sometimes the object of their inclusion in a paste is to alter the flow properties or to produce a flatted surface. The substances most commonly used are ground and precipitated calcium carbonate, barytes and calcined kaolin clays. Also used are silicas, micas, and diatomaceous earths.

The presence of large amounts of fillers in a paste is undesirable since its fluidity depends—partially at least—on the surplus plasticizer which, by lubricating suspended particles, permits freedom of movement. Excess filler will obviously tend to absorb plasticizer. There are several ways of overcoming this, e.g. incorporation of high viscosity plasticizers or utilization of a filler having a low oil absorption value.

The oil absorption value of a filler is a measure of the capacity of the filler to absorb plasticizer. The higher the oil absorption value, the greater is the increase in paste viscosity. The oil absorption value is usually taken as the weight of oil absorbed by 100 parts of filler. It is generally agreed that for low oil absorption the particles should be roughly spherical and have a certain particle size distribution. Although oil absorption values of a filler cannot be taken as a significant property they are nevertheless useful in estimating the effect a filler will have on the flow properties of a paste.

Approximate oil absorption values for typical fillers are given below:—

Barytes	16
Slate powder	30
Dolomite	33
Whiting	36
China clay (medium fine) ..	35
Silica	42
China clay (very fine)	55
Water ground mica	79

If allowance is made for the plasticizer requirement of a filler, the loading may be increased without affecting paste viscosity. The limit is then solely determined by the reduced physical properties of the fused film.

While fillers should be finely ground they should not be too fine since paste viscosity increases with decreasing particle size. For example, a good china clay would consist of a grade in which 5% of the particles are smaller than 1μ and 50% retained by a 200 mesh screen. A clay with 80% of the particles smaller than 1μ would produce a very high viscosity paste.

Table III illustrates the effects of seven fillers on the viscosity, tensile strength, modulus and elongation of cured films based on Geon 121/DOP paste.

The volume of each filler added was equal to that of 20 parts by weight of calcined clay.

It is generally recommended that fillers should be pre-ground with some of the paste and then dispersed in the bulk of the batch.

Pigments

Pigments serve two functions besides decoration—stabilization and loading; both are of great importance. Although there are some pigments which on account of chemical reaction with the vinyl polymer cannot be used—e.g. iron and zinc pigments—there are a great number of pigments which can safely be used, enabling an almost unlimited colour range to be produced.

It is always advisable to take the manufacturer's recommendations but the final choice of pigment should always be founded on basic work done by the user, since colour stability and actual colour will depend on variations in both quantity and type of plasticizer and stabilizer and probably also on the type of polymer used.

There are also many organic colours which are completely suitable for p.v.c. Here again it is advisable to be guided by the manufacturers.

Lead stabilizers should be avoided in the presence of pigments showing poor light stability. If there is a tendency to migrate or bleed, inorganic stabilizers should be used.

Heat stability is reduced by the presence of pigments containing manganese, zinc, magnesium, cobalt, copper, chlorine, small amounts of iron, and free sulphur. Pigments containing tin, calcium, barium, cadmium and as mentioned above, lead, do not affect stability and may, in fact, improve it.

Pigments act as stabilizers in that they possess actinic screening properties, thus lessening the degree of break-down of polymer by U.V. light. Their use as fillers or extenders follows the pattern of the conventional types of filler described earlier.

Dispersion of pigments is a serious problem. Unless agglomerates are thoroughly broken up and dispersed the final p.v.c. coating may show signs of streaks. Pigments are usually added in the form of separate pigment pastes or concentrates consisting of the pigment finally ground in plasticizer. Such concentrates are prepared either on a ball mill or a three-roll mill. The amount of pigment suitable for spreading pastes is about 15–20% of the resin/plasticizer content.

TABLE III

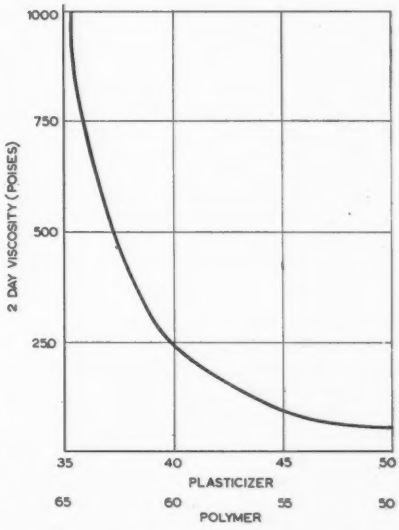
EFFECT OF FILLERS ON GEON 121 PASTE COMPOUNDS

Filler	Parts used	Viscosity cps. 1 day	T.S. p.s.i.	M. 100% p.s.i.	E.B.	Oil absorption No.
Control	Nil	10,000	2,400	1,000	350	—
Calcined clay	20	17,000	2,050	1,125	340	66
Blanc Fixe	30·9	15,000	2,250	1,100	320	38
Pptd. $CaCO_3$ (low oil absorption)	20·9	18,000	2,100	1,000	350	36
$CaCO_3$ (high oil absorption) ...	20·4	40,000	2,250	1,100	370	45
Barytes	34·4	7,000	2,200	950	420	16
Diatomaceous earth	17·7	40,000	1,900	1,175	270	148
Lithopone	33·1	40,000	1,750	1,000	320	37

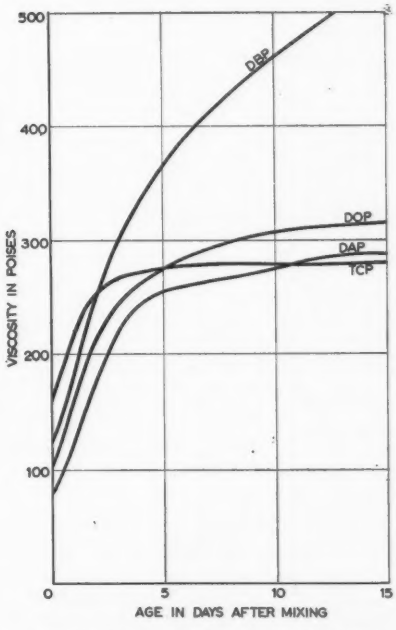
Compound : Geon 121 100
Dioctyl phthalate ... 66
Filler ... ... Variable

Preparation of p.v.c. Pastes

There are two basic requirements in the formulation of a vinyl paste: it must have flow properties sufficient for the intended application and it must produce a film having the desired end properties after fusion. Both these factors are governed by the type of ingredients used, their proportions and the method of preparation.



Variation of viscosity with plasticizer content.



Change of viscosity on ageing with four different plasticizers.

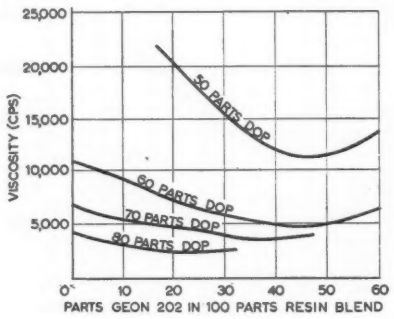
The usefulness of a paste is influenced by two main factors: the paste must not be dilatant, and it must be easily spreadable by suitable equipment.

A fluid exhibiting dilatancy is one in which the viscosity increases with increasing rates of shear.

Dilatant pastes may not provide much

trouble under average spreading conditions. They will cause difficulties only if the spreading rate is speeded up, thereby increasing the rate of shear.

It is clear that a vinyl paste should have a reasonable shelf life. Here again, opinions vary

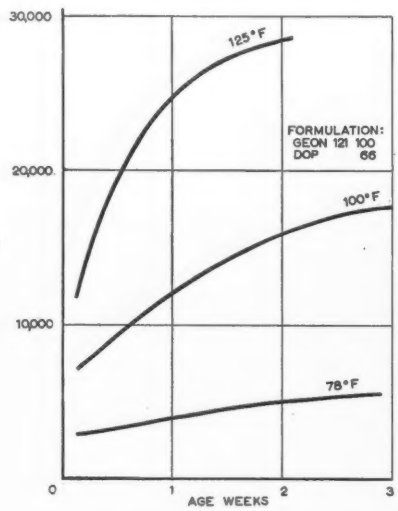


Viscosities of Geon 121/202 pastes.

as to the minimum shelf life acceptable, but a good general guide is that a paste having an initial viscosity of 5,000 cps. should not change by more than 100% after one month's storage.

A paste consisting of 60/40 p.v.c./d.o.p. will have an initial viscosity of about 10,000 cps. increasing to not more than 15,000 cps. after two days' ageing.

Low-viscosity pastes, with viscosities of 20,000 cps. or less, are prepared by adding all the resin to one-third to two-thirds of the



Effect of temperature and age on paste viscosity.

plasticizer in a pony or dough-mixer and mixing thoroughly until a smooth homogeneous mass is attained, taking care to keep the temperature of the mix below 32° C. by water cooling or periodic breaks in the mixing. During the mixing, pigments, stabilizers and fillers are added as dispersions in plasticizer. The paste is then diluted with the remainder of the plasticizer, this being added in several lots. The viscous mix can also be passed through a roll mill prior to dilution in order to effect more thorough dispersion of the ingredients. Ball mills may also be used for the manufacture of such pastes.

High viscosity pastes are best prepared by adding the resin in small portions to the plasticizer and other components. In the preparation of these pastes it should be ensured that the rate of mixing is not so high as to generate too much heat. If this cannot be avoided adequate cooling should be provided.

Storage

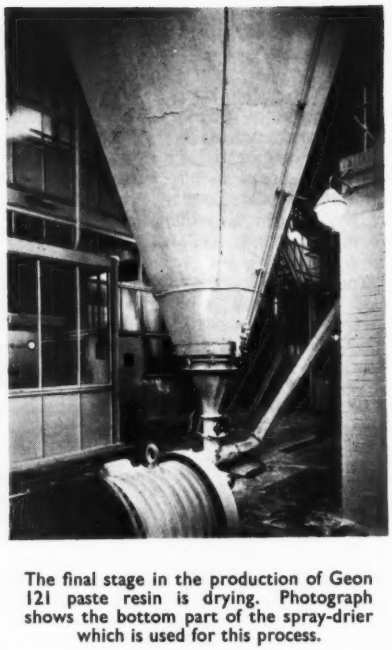
Vinyl pastes are stable under normal atmospheric conditions but the polymer is susceptible to decomposition when in direct contact with certain metals. Iron and zinc initiate and catalyze the decomposition of the resin and steel or galvanized containers should therefore not be used. The shelf life of a p.v.c. paste decreases with increasing temperature because of viscosity increase. The ideal storage temperature is in the region of 16°–27° C.

The viscosity of pastes is influenced by the following factors: amount and type of plasticizer, fillers, pigments, stabilizers, method of mixing, age of paste after mixing, and storage temperature.

Properly formulated and compounded pastes have been stored for several years without any detectable deterioration. Generally speaking, however, the viscosity of a paste does increase with its age. This increase is generally somewhat erratic up to about 48 hours after mixing, after which it becomes fairly steady. This has been attributed to the solvating action of the fluid medium upon the resin particles. Setting out of resin sometimes occurs after prolonged ageing but this deficiency can easily be eliminated by minor changes in formulation.

Deaeration

Retention of air by a p.v.c. paste is not determined by viscosity alone; surface and interfacial tension are two important factors which influence the degree to which air becomes occluded and the ease with which it is dissipated. Other factors which often have direct

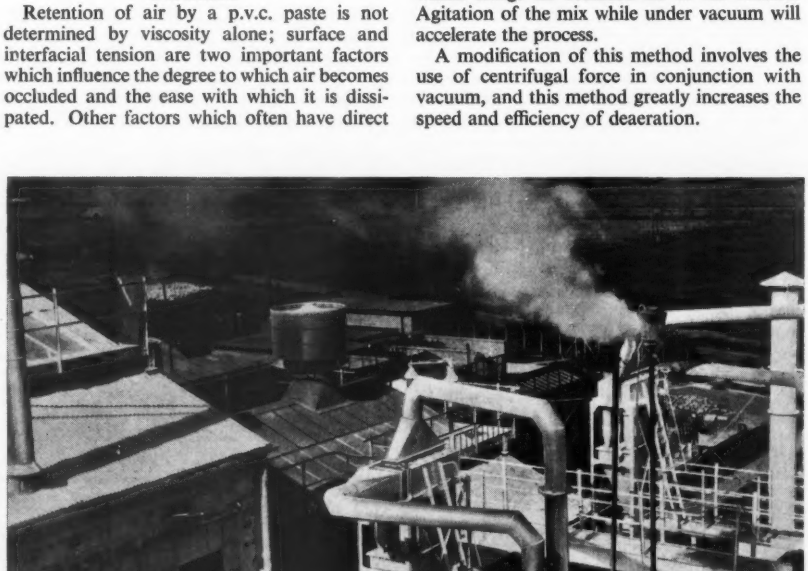


The final stage in the production of Geon 121 paste resin is drying. Photograph shows the bottom part of the spray-drier which is used for this process.

bearing on the occlusion of air are the type of resin and plasticizer used and the method of manufacture. Some pastes only require time—varying from a few hours to some days—for spontaneous deaeration.

Most pastes, being relatively viscous fluids, require mechanical deaeration. There are several ways of doing this, the most common being the application of a vacuum to the paste, which brings all occluded air to the surface. Agitation of the mix while under vacuum will accelerate the process.

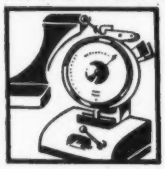
A modification of this method involves the use of centrifugal force in conjunction with vacuum, and this method greatly increases the speed and efficiency of deaeration.



A view from a catwalk at the top of the Geon 121 paste resin plant at Barry.

World's Industry Employs Plastics

MATERIALS and TESTING



Casting resins in electronic circuits.—A review of the different synthetic resins which can be employed in potting and encapsulating electronic circuit sub-units has been prepared by H. L. Loucks. The resins dealt with include polyester and epoxy resins, foam type resins such as polyisocyanates and polystyrenes, and elastomeric resins such as polysulfides and silicone rubber compounds.
(*Materials and Methods*, 1956/Feb./90.)

P.V.C. suspensions with improved properties.—In a short review, Wick and Weber emphasize principally the qualities required of p.v.c. emulsions for special purposes, more particularly for dipping. They stress the need especially for avoiding occluded air and adsorbed water and the need for care in choice and compatability of extenders and plasticizers. Among other requisite properties noted is that of maximum shelf life.
(*Kunststoffe*, 1956/May/199.)

Individualistic finishes for plastics.—Attention is drawn to a demonstration set of novel surface finishes and designs for plastics at the Institut für Industrieform, in the Werkkunstschule at Krefeld. The æsthetic disadvantages attaching to the practice commonly followed hitherto of imitating in plastic and plastic-coated materials the appearance of leather and so on, is commented upon and two examples of roll-embossed forms based on marine life are given.
(*Kunststoffe*, 1956/May/203 (Adv. page, 43).)

New fabric produced by shrinking.—A three-dimensional fabric is now being produced by incorporating a pre-stretched polythene monofilament. The filament is woven into a fabric made from the more conventional yarns on a normal loom and can be incorporated in either the weft or the weave or both depending on the pattern required. The knitted fabric is then dipped into boiling water which shrinks the polythene as much as 55% thus giving the three-dimensional effect.
(*Materials and Methods*, 1956/Feb./147.)

INDUSTRIAL APPLICATIONS

Ziegler polythene pressure tube.—Test results and practical experience of the use of "low pressure" polythene pipes, more particularly for company's water, are discussed by Richard and Diedrich. The authors consider the favourable economics of this material as compared with metal, its generally favourable chemical properties and its mechanical properties, especially with respect to water-hammer and to stressing under conditions of thermal expansion and contraction both when fixed externally and when buried in plaster. Practical joining systems are noted.
(*Kunststoffe*, 1956/May/183.)

P.V.C. insulated telephone wires.—Replacement of the normal rubber-and-textile insulation for telephone conductors by straight forward p.v.c. coatings, introduces difficulties in connection with provision of colour identification. Two Swiss companies have solved the problem by extrusion coating the tinned copper wire on specially designed equipment with various coloured p.v.c. mixes, the composition of which must be carefully regulated to preserve high electrical qualities. Operating principles of two different types of equipment are given.
(*Kunststoffe*, 1956/May/208.)

Plastics clad aluminium pistons.—A new piston developed by the Cleveland Pneumatic Tool Co. for use in the hydraulic shock-absorbers on aircraft landing gear employs an aluminium core to which is bonded a thermoset laminate. After the laminate is bonded to the core the resin is polymerized and the piston machined to size. Advantages claimed for this new piston are its lightness and dimensional stability the latter property being most important in that it prevents "seizing."
(*Design News*, 1956/Feb. 15/42.)

Phenolic clutch cone.—A moulded cone has been incorporated in the clutch mechanism of an American automatic screw machine. Trouble was found when the continuous rapid engaging and disengaging of the clutch caused over heating and wear. A chopped fabric reinforced phenolic cone with a steel ring moulded in is now being used successfully.
(*Design News*, 1956/Mar. 1/42.)

Subminiature resistor.—A precision wire-wound subminiature resistor designed for use in guided missile computor, and instrument applications is encapsulated in mineral filled epoxy resin. The filler dissipates heat and equalizes hot spots in the windings.
(*Electronics*, 1956/May/286.)

Protected glass pipe.—A seamless sleeve of glass fibre impregnated with polyester resin is fitted over the exterior of the glass pipe. The sleeve forms an armour against rough handling and also is designed to carry the same work load as the pipe in case of glass failure. It is sufficiently transparent to allow the liquid level in the pipe to be visible.
(*Product Engineering*, 1956/Feb./230.)

MISCELLANEOUS USES

Polythene bags for transporting cream.—Shipping cream from the dairy to the creamery where it is turned to butter is carried out by one company in Illinois, U.S.A., by means of polythene bags. Four bags, each holding approximately 10 lb. of cream are transported in cartons. Savings in weight by using these bags amount to 82% and in space 50% with consequent savings in transport costs. Quality of the cream is also reported higher.
(*Food Engineering*, 1956/Apr./62.)

Linked polythene packages.—A welded polythene bag heat sealed into ten separate compartments is now being used for the packing of small grinding wheels. Besides affording greater protection to the wheels it also enables quicker counting and simpler handling. Each compartment of ten wheels can be detached from the main package when required.
(*Flow*, 1956/March/118.)

Synthetic fibre ropes.—A review of the different synthetic fibre ropes and a comparison between them and natural fibre ropes is given. Nylon gives better results for long tows because of its stretch but manila gives better control on short couple tows.
(*Marine Engineering*, 1956/Apr./86.)

Glass reinforced polyester in searchlight.—Glass reinforced polyester, selected for its high dielectric stability and insulating qualities, is being used by the U.S. Navy and Coast Guard as a protective spark-gap insulator in an 8 in. sealed beam Xenon arc searchlight.
(*Design News*, 1956/Apr. 1/40.)

Developing design data for plastics.—More complete data than are usually available on plastics are necessary to permit designers and engineers to adequately design plastics structural products. To illustrate this point the authors, R. K. Multer and R. H. Rayfield, present the latest engineering data on a thermoplastic polymer containing acrylonitrile, butadiene and styrene.
(*Materials and Methods*, 1956/Apr./132.)

Automatic recording tape cartridges.—An injection moulded cartridge which holds a continuous-loop type of recording tape has been developed by Cousino Inc., of Toledo, Ohio. After recording the message, the tape is rolled up on the cartridge spool and the casing assembled. The unit can be inserted, played, and removed from specially designed equipment without the tape being touched.
(*Product Engineering*, 1956/May/224.)

Resins for reinforced plastics.—Ernest Schlieben gives a review of the functions of the resin in a fibre reinforced structure and also what would be the requirements of an ideal resin. After touching on some of the problems in moulding Mr. Schlieben deals individually with the polyester, phenolic and epoxy resins pointing out their advantageous properties and limitations. He also suggests moulding techniques which give the best results.
(*Product Engineering*, 1956/May/198.)

Twin-tube extrusion for manometer.—A clear one-piece dual tube extrusion in cellulose acetate butyrate forms the main constructional element of an industrial manometer and replaces the normal glass tubes. Two mouldings containing ball-check and shut-off valves complete the assembly. Considerable savings in material and assembly costs are effected by the use of plastics components in addition to the added strength of the instrument.
(*Materials and Methods*, 1956/May/140.)

Future for plastics pipe.—An evaluation of the future use of plastics pipe in different industries, compiled by Monsanto, estimates that over 50 million pounds of plastics pipe will be in use in 1975. Largest potential increases in industry is expected in the petroleum industry. Gas, water, and sewage and waste disposal run close seconds with agricultural uses also an important market for development. A guaranteed standard of plastics pipe is an essential factor in the expansion of these markets.
(*Chemical and Engineering News*, 1956/Apr. 9/1809.)

Plastics Tooling in America

By
T. A. DICKINSON

A report on materials and methods in general use

(Left) Typical plastics tooling department in U.S. factory.

WHILE virtually all natural and synthetic resins now have certain tooling applications in the United States, only four types are generally regarded as basic tooling plastics. They are epoxy resins, ethyl cellulosics, phenolics, and polyesters.

Practically all of these materials have been bitterly denounced at some time or another by tooling experts. However, experience has consistently shown that the " deficiencies " of tooling plastics are attributable to the sort of misuse and abuse that would cause any material to give unsatisfactory results.

General characteristics that make the tooling plastics attractive to American tool and die men include castability (and quick curability) at low temperatures in any thickness, dimension, or mass; dimensional stability, despite climatic conditions such as humidity; high mechanical strength properties; light weight; resistance to oil, water, acids, alkalis, and solvents; reinforcability with materials such as glass fibres; machinability with standard metal and woodworking tools; and availability at reasonable prices.

Phenolics

Phenolics are the oldest tooling plastics, having been in use as die materials almost 20 years. However, they did not attain the widespread approval of American tool engineers until about 1950.

A typical application for phenolics involves the fabrication of stretch dies which are used in forming sheet metal parts. Die construction varies with the individual imagination, and each company appears to have its own likes and dislikes. Bases or back-up plates have been made from plywood, masonite, aluminium, Kirksite, and steel. Cores or internal structures have utilized concrete, wood, pumice, gravel with resin binder, foamed plastics, etc. And, as a rule, the facing over which the sheet metal is stretched is a 1½-in. to 2-in. thick layer of cast phenolic.

One type of stretch die that has proved production worthy in several plants comprises a 1 in.-thick steel base with welded-on I-beams, a foamed phenolic core, and a solid phenolic face.

Another important application with widespread usage of cast phenolic is found in draw die tooling. Die construction varies with the individual companies, but generally utilizes a combination of steel or Kirksite with the phenolic as the surface that contacts the part. A typical construction consists of a solid phenolic punch, a Kirksite plastic-faced draw ring, and a phenolic-faced female die surrounded by a steel weldment box.

Several companies report that such materials as 75S aluminium, ¼ hard stainless steel, and pure titanium have been formed on double-action phenolic draw dies.

The cast phenolic resins used today are either heat cured (about 180° F.) or room temperature cured, depending on the equipment available for mixing, pouring, and curing. Both types are thermosetting and when cured are not reclaimable.

The resins, however, are relatively inexpensive; and since they can be cast to shape and are dimensionally stable, the resultant tools require little or no hand finishing. The resins, catalysts, and fillers are easily mixed and cast and can be worked with standard woodworking equipment. Repairs or changes are easily made since new resin can be added wherever necessary.

Phenolic tools are usually light in weight and easily handled. A typical stretch die made of phenolic weighs about one-fourth as much as a Kirksite die and can be made in about one-third the time.

Ethyl Cellulosics

Another of the older plastic tooling materials is ethyl cellulose. It has a potential which is still being developed.

Ethocel resins are compounded for melting as small blocks or pellets with various degrees of hardness and flexibility, depending upon the end application. Shore hardness range is from 30 to 90.

These resins are reclaimable and reusable. However, they require a melting kettle or heated equipment for handling.

Their main uses to date are in drop hammer punches, pressure rings for draw dies, fillers for stretching or bending formed sections or tubing, and fillers for forming integrally stiffened parts—such as wing panels, control surfaces, and leading edges for aircraft.

For drop hammer punches, the ethocel is sufficiently elastic to yield to the part thickness in the forming operation. Therefore, an allowance for material thickness is not required in making the tool.

Epoxy Resins

Although they have been available for less than five years, epoxy resins are by all odds the most popular tooling plastics in the United States at present. And it has been reliably estimated that 10,000,000 lb. of these materials will go into American industrial tools during 1956 alone.

The current prominence of epoxies is attributable to chemical compatability with numerous additives such as aluminium powder, silica, vinyl resins, polyamides, acrylonitrile, polyesters, melamine, and Thiokol rubber. This makes it possible to obtain numerous combinations of physical properties for casting and laminating applications.

In addition, the epoxies may be cured in almost any desired manner—with heat or at room temperature—with a variety of commercially available catalysts.

Tools being made from epoxies include draw dies, moulds for reinforced plastics, stretch dies, post-forming moulds, and drop

hammer dies. Components of the latter types weigh only 5% as much as comparable metal tools, which have an 80% greater cost.

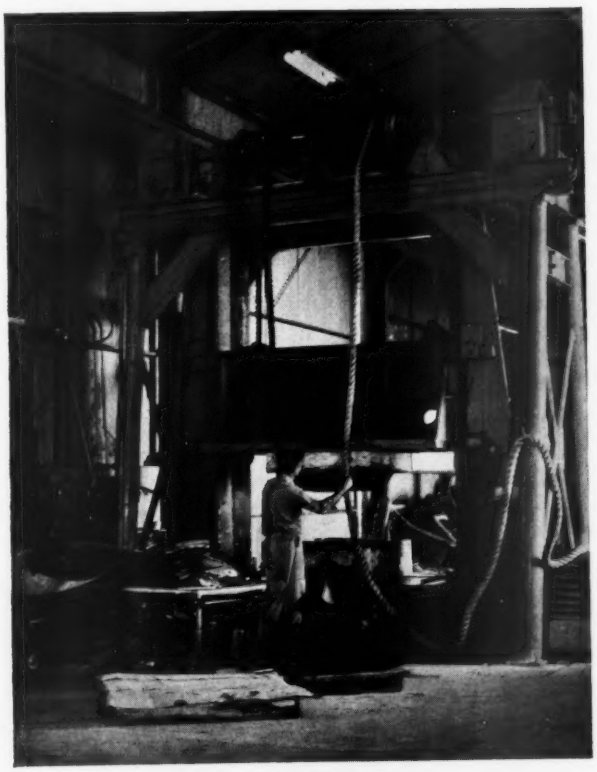
Further, epoxy tools have a number of special properties which are both unprecedented and important. For example, the drop hammer dies may have soft yet tough faces which have no tendency to scratch or mar sheet metal parts.

A recent report from North American Aviation, Inc., indicates that typical epoxy tools (for the fabrication of a complicated corrugated duct from stainless steel) have been made as follows:

" The inside surface of the duct was dummied up with plaster masters. Each male master was scribed with proper reference lines, and contours for additional tools were retained by making plastic splashes. The latter consisted of 4-piece segmented female epoxy laminates which, when reassembled, formed a complete section of the contoured duct. These splashes consisted of a cast epoxy surface coat reinforced with glass laminate and supported by steel plates and plastic tubing.

" Corrugations were formed by pouring flexible epoxy resin into a female mould and curing. These were then attached to the proper line on the master by flathead wood screws. Plaster splashes and resplashes were then made of the corrugated sections. Clay $\frac{1}{4}$ in. thick was then applied to the surface of the splashes for making of plaster cores to make the rough Kirksite castings. These Kirksite castings form the inner core of the form dies.

" The plaster splashes of the corrugated masters were next stripped of the clay and prepared with fillers and coatings to smooth the plaster surface and to afford proper parting from the cast epoxy dies. The Kirksite cores were then rough ground or sand blasted to remove oxidation, coated with a surface coat of epoxy resin, and boxed in with the prepared plaster splash for pouring the rigid type epoxy resin surface. This tool became a male stretch die and also doubled as the punch for a drop hammer sizing operation.



Ethyl cellulose die used in hammer forming sheet metal.

Epoxy dies used in forming afterburner nozzles from superalloy steel (Ryan Aeronautical Co.).

" A female Kirksite core was prepared in a similar manner. The male die was coated with a wax type parting agent and $\frac{1}{4}$ in. thick plastic spacers were applied to the corners. The Kirksite core was boxed in with the matching male die. This time a flexible type epoxy resin was poured into the $\frac{1}{4}$ in. space and cured. This made a matched tool and did not require material thickness allowance because the flexible resin displaced a sufficient amount.

" In using these tools to fabricate a part, the following procedure is employed: The flat stock is pre-drilled to the correct pattern to align the resultant corrugations in the proper place. Then the holes are indexed on a brake die and each corrugation is formed one at a time. After forming, the ends of the panels are flattened so that they will slide into the stretch jaws.

" The male form die is mounted on the stretch press and the part is stretched to contour. After an annealing and pickling operation the part is then sized on the matched drop hammer tools.

" An epoxy-glass laminate scribe fixture is used to rough-trim the part. These details are then assembled on an epoxy jig (of which the male member is epoxy glass cloth laminate) for spot welding together with an inner skin to form the duct assembly.

" This use of epoxy resins has demonstrated the feasibility of tooling complicated parts to close tolerances to achieve production parts in minimum time."

Polyesters

Polyester resins are principally important as binders for glass fibre materials which are used in the fabrication of laminated tools—such as spot-welding fixtures, Keller patterns, installation and assembly jigs, hydraulic press forming accessories, drill and trim fixtures, etc. Such tooling requires a combination of light weight, high mechanical strength, and minimum cross-sectional thickness.

Due to relatively high material costs, polyester-glass laminates are more expensive than other types of plastic tooling on a straight weight basis. But thanks to recently-improved polyester resins and catalysts, they are being made with exceptional speed and ease.

For example, the Convair division of General Dynamics Corporation at San Diego, California, currently uses a cold-curing polyester resin and glass fabrics to make such tools as drill jigs and inspection fixtures as follows:

(1) One plaster form for each tool is made by splash-casting a material such as Hydrocal in accordance with standard foundry pattern-making procedures. Then the form is sealed with three spray coatings of lacquer and, if necessary, provided with wax

edge strips to establish the lamination boundaries for the tools that will be produced.

(2) A liquid wax product is applied to the lamination surfaces of each plaster form prior to the fabrication of each tool in order to prevent the adhesion of laminae to the plaster surfaces.

(3) Glass fabric laminae are cut to the dimensions specified for individual tools by means of scissors, then each is impregnated by coating its surfaces with the catalysed polyester resin with a paint brush. The latter operation is usually accomplished after the laminae are respectively stacked on a plaster form. (The number of layers of fabric used in laminating a given tool depends on the size and purpose of the tool. As a rule, this does not exceed four layers.)

(4) In most cases, the catalysed plastic materials on the fabric laminae are allowed to solidify in open air at room temperature in a period of about four hours. However, where it is desirable to shorten the curing interval, due to cold weather or unusual production requirements, the tooling laminates can be bonded in an hour or less with heat from ordinary light bulbs situated an inch or two away from the uppermost tooling surfaces.

Laminate surfaces exposed to air during the curing interval are usually a bit rough; but, if necessary, they can be satisfactorily smoothed out with standard sanding and grinding facilities.

Solidified tooling laminates can also be sawed, drilled, planed, shaped, etc., where special details (such as bushed holes for drill jigs) are required.

Metal inserts and parts adjacent to the laminated tooling surfaces are definitely not subjected to the sort of chemical action that promotes corrosion, although they may be lacquer finished or otherwise protected against atmospheric corrosion.

Convair's laminated tooling is very difficult to damage; but if damages should occur, the jigs and fixtures could be readily repaired by returning them to their plaster forms for supplemental lamination operations.

Wax edge strips are added to a plaster form which will be used to laminate glass fabric with a cold curing polyester resin (General Dynamics Corp.).

Similarly, many types of engineering changes can be incorporated in the tools without difficulty. For example, if it were desirable to change the location of a hole in a drill jig, the following procedure would apply:

(1) Remove bushing from the hole that is no longer needed.

(2) Fill the latter hole with resin-impregnated fabric and allow it to cure.

(3) Drill new hole and press-fit bushing therein.

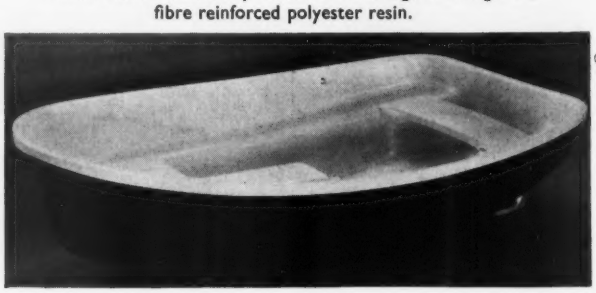
A dozen or more duplicate tools can be laminated, if necessary, with a single plaster form.

New Productions

Yacht Tender

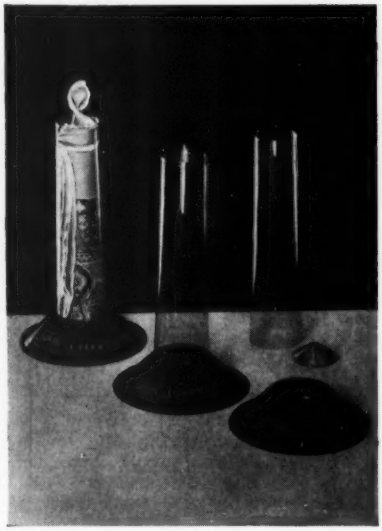
Latest addition to the now considerable number of small dinghies, is the " Shorty " yacht tender, produced by Maximar Mouldings, Ltd., of Pulborough, Sussex, and moulded in glass fibre polyester resin. The designer of this dinghy, Mr. John Westwell, has borne in mind the ease with which compound curves can be produced when moulding this material. The construction of the dinghy, as can be seen from the illustration, is in two parts—the hull constructed in a female mould, which gives a smooth exterior finish, provides one part; and the inner hull with integral moulded thwarts, non-slip treads and rowlock bushes is constructed on the complex male mould. The two halves are bonded together giving a dinghy of high strength and by its very construction one which is virtually unsinkable. The " Shorty " has a 4 ft. beam and 6 ft. 6 in. overall length, with a total weight of about 60 lb. The resin used in its construction was " Beetle " polyester resin, supplied by B.I.P. Chemicals Ltd.

Yacht tender moulded by Maximar Mouldings Ltd. in glass fibre reinforced polyester resin.



Scarf Display Pack

An attractive and novel pack has recently been introduced by the manufacturers of " Sammy " scarves. This pack, which has been designed and developed by Universal Metal Products, Ltd., in conjunction with Stowe and Bowden, Advertising Agents, and manufactured by the former company, is constructed entirely from acetate sheet. It is particularly interesting in that three manufacturing techniques are employed in its production.



Scarf display pack.

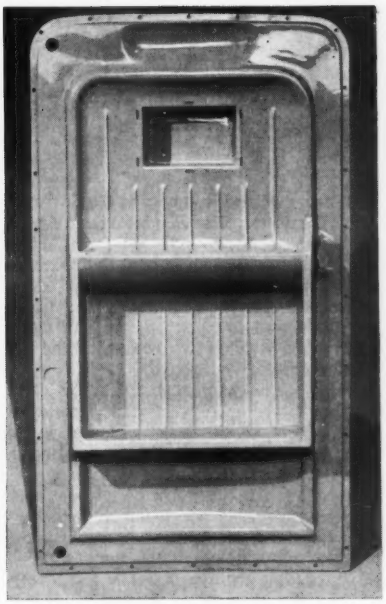
The base is vacuum formed after being printed on a multi-impression mould from black 20/1000 in. "Cellastine" sheet. The cylinder is fabricated from transparent 7½/1000 in. "Clarifoil" and the cap, also formed from this material, is press formed. The small hole is punched in the centre of the cap while it is being formed, through which a corner of the scarf is pulled to represent the flame of the "candle."

Jewellery Casket

One of the latest mouldings produced by Plastiers' Ltd., Reliance Works, 305–315 Hithergreen Lane, London, S.E.13, is an attractive jewellery casket, a photograph of which we reproduce here. The casket is injection moulded in Styron 666, supplied by British Resin Products, Ltd.

Refrigerator Door Panel

An excellent example of the vacuum forming technique is illustrated by our photograph of the Nash-Kelvinator inner door panel for their refrigerator. Made from high impact polystyrene sheet it measures approximately 2 ft. by 3 ft. 6 in., and has been formed by Thermo-Plastics Ltd., of Luton Road Works, Dunstable. Its design as can be seen calls for both shelving and a recess which necessitated the adoption of the drape forming technique.



Vacuum formed refrigerator door panel.

Vacuum Formed Display

Used as the focal point in an advertising display for Pirelli motor tyres this hub disc has been vacuum formed by the K. R. Webb Printing Co., of Painswick. The material used is extruded styrene copolymer sheet made by Erinoid Ltd.

After forming, the disc is metallized by A. E. R. (1938), Ltd., before being printed. A special technique of printing on the formed surface was developed by K. R. Webb for this order.

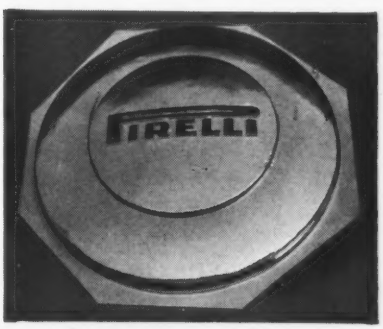
Protective Gloves

Interlock Terylene fabric supporting a transparent p.v.c. film is the material used in the manufacture of these gloves. Developed and made by Commander J. C. Watkins and Major L. Hill of Glove (Industrial) Manufacturing Co. Ltd., Waterloo Road, Linslade, Leighton Buzzard, they are used for protecting H.M. Forces working with guided missiles, rockets and certain jet type motors where high-test peroxide is used.

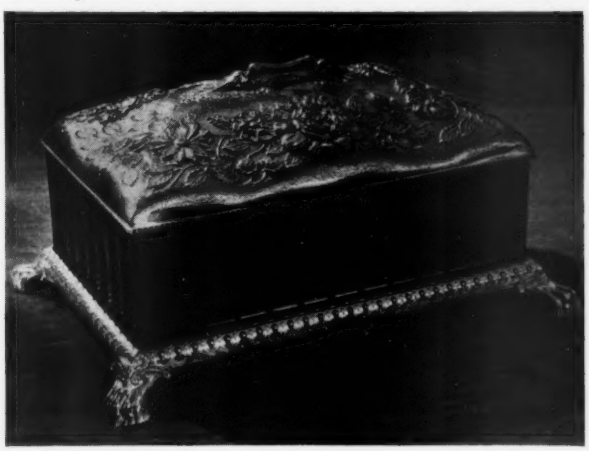
Machined acrylic film spool.

Film Spool

Unlike the majority of film spools produced to-day, which are injection moulded the one we illustrate is machined from acrylic sheet and assembled later. It is used in conjunction with X-ray film, the slots in the flanges of the spool being so arranged and angled that the whole film is developed. This intricate machining is carried out by General Plastics Ltd., Marden Works, Pattenden Lane, Marden, Tonbridge, Kent. The spool itself has been designed and is produced for Kodak Ltd.



(Right) Vacuum formed display unit



(Left) Injection moulded jewellery casket.

(Right) Terylene and p.v.c. protective gloves.

Plastics NEWS

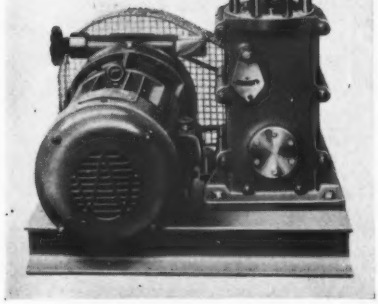
Plant and Equipment, Materials, Processes, Company News, Technical Literature, Exhibitions, Personal Notes, and Meetings.

VACUUM FORMING SAMPLES.—Our illustration shows a new American bench-type vacuum forming machine which has been designed for use in making prototype parts or sample packets. The machine is known as the

American bench-type vacuum forming machine.

Lab-Vac and has a maximum forming area of 16 in. by 16 in. It is fully equipped with drape mechanism with 7 in. stroke, clamp frame, heater, vacuum pump and reservoir tank. The Lab-Vac is produced by the Auto-Vac Company, 1986 State St. Ext., Bridgeport 5, Conn.

WAVE PULSE GENERATOR.—As the direct result of over four years of research into wave and sonic energy transmission through liquids, a new wave pulse generator has been developed. This apparatus has been produced by D.F. Developments Ltd., 175 Piccadilly, London, W.1, who specialize in mechanical vibrating equipment.



Wave pulse generator.

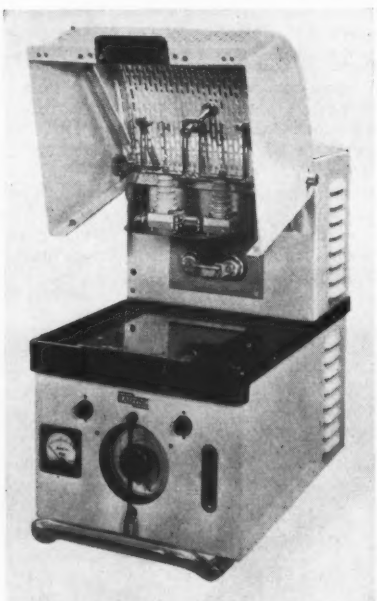
The new machine is known as the Sonomec Energy Generator. The Sonomec is, in fact, a mechanical vibrator with great variability within the frequency range of 0 to 200 cycles per second. It consists essentially of a mechanically driven disc diaphragm which transmits vibrations to either liquids or solids placed in the 1 gallon capacity processing pot of the apparatus.

The linkage mechanism, driven by the 2 h.p. electric motor, incorporates a means of adjusting the amplitude of vibration in an infinitely variable manner. Frequency also can be varied without stopping the machine.

Some of the processes in connection with both liquids or solids which can be performed by the Sonomec are intense or intimate mixing, impregnation, wetting, emulsifying, separating and segregating, artificial maturing and ageing, and testing to limits of endurance or destruction.

Large capacity Wave Pulse Generators can be designed and supplied for carrying out processes on a commercial scale.

R.F. PLASTICS, PRE-HEATER.—The new ¾ kw plastics pre-heater, model H6/A produced by Radio Heaters Ltd., Wokingham, Berkshire, incorporates several new advances combining them with a low cost price. Principal technical feature in its construction is the replacement of mercury rectifiers with Xenon rectifiers. These rectifiers are for all practical purposes insensitive to extremes of temperature, with the result that a long life is far more likely to be achieved. It has also been possible to increase the power output by 50% giving a plasticizing capacity of phenolic powder of ½ lb. per minute.



R.F. Plastics pre-heater.

The lid of the pre-heater is operated automatically by the time clock which is of the automatic re-setting type and is adjustable between one second and ten minutes. The oven will accommodate objects up to 11 in. by 9 in., the actual heating area being approximately 5½ in. by 6 in. and the total weight of the machine is approximately 180 lb.

JAPANESE SYNTHETIC RESIN OUTPUT.—The Japanese Ministry of Trade has set the production target for synthetic resins for the 1956/57 financial year at 133,000 tons, compared with 100,000 tons for the previous year, the Ministry said.

The major items of the estimated output are 55,000 tons of vinyl chloride against 40,000 tons in the previous year, 50,000 tons of urea resin against 35,000 tons, and 14,300 tons of phenol resin against 12,400 tons.

The 30% increase in production was based on the ground that demands for vinyl chloride, urea resin and phenol would substantially increase, the Ministry said.

The main items covered by the announcement are as follows (in tons): vinyl chloride, 55,000; urea resin, 50,000; phenol resin, 13,400; methacrylic ester resin, 1,200; alkyd resin, 5,200; polyester resin, 1,000.

General

New Spray Gun.—Alfred Bullows & Sons, Ltd., of Long Street, Walsall, Staffs., have recently introduced a new spray gun. It has been designed to give good balance with the minimum of weight. The trigger design is such that it allows the operator's finger to lie naturally along its full length, giving accurate control by very light pressure. The body is a duralumin forging with all wearing threads in brass inserts. It is primarily intended for matching and shading work and for the production painting of small articles where a high rate of paint flow is unnecessary.

Helical Clamps.—The Rockwell Machine Tool Co., Ltd., Welsh Harp, Edgware Road, London, N.W.2, are now marketing the Rockwell helical clamp. These clamps have a helical "staircase" consisting of small steps extending around the axis of the clamping bolt. This "staircase" supports the lower stepped end of the clamp supporting member, which is arranged for rotary adjustment about the clamping bolt. The supporting clamp carries an off set clamping strap arranged for longitudinal adjustment in a groove formed in the upper surface of the supporting member. The clamping strap can be reversed by 180°. A compression spring between these two members greatly facilitates desired height adjustment. The clamps are manufactured from high grade spheroidal precision castings. The clamping bolt and the tubular but are manufactured from heat treated steel. The clamps are available in a large range of sizes.

Cellular p.v.c.—We have pleasure in informing readers that the expanded p.v.c. insulation structures (key, joints, etc.), noted in the article "Cold Beer in Equatorial Africa" were made of "Klégécell," a new cellular p.v.c. produced by a specially controlled process, by Kléber-Colombes of Paris. We also announce that Plastudy, Ltd., of 32 Victoria Street, London, S.W.1, holds the British rights to the material, and we understand that it is marketed in this country under the name "Plasticell."

New Petrochemical Plant.—As a first step towards meeting the steadily increasing demand for ethylene and propylene derivatives, Petrochemicals, Ltd., one of the Royal Dutch/Shell Group of Companies, has started work on an extension to its Partington plant, near Manchester. Expected to be in full operation by mid-1958, these new facilities will include a plant for the production of some 25,000 tons per annum of ethylene oxide. This plant will employ the process worked out by Shell Development Co. in the U.S.A. for the direct catalytic oxidation of ethylene. A new plant for the conversion of ethylene oxide to ethanolamines came into operation in January of this year and additional capacity for glycol ethers, polyglycols and non-ionic surface active agents is in course of construction. On completion of the direct oxidation plant the existing ethylene oxide plant will be used to expand the present production of propylene oxide.

New Polythene Monofil.—Courtaulds Ltd. are developing a new type of monofil of polythene known as Courlene X.3. The most significant differences between Courlene X.3. and standard Courlene are in the strength, the resistance to abrasion, and the effect of heat.

Courlene X.3. is comparable in strength to the polyamide fibres. Tests carried out to date indicate that its resistance to abrasion is also similar to that of nylon. All polythene fibres melt at relatively low temperatures, but whereas the softening point of standard Courlene is about 90° C., that of Courlene X.3. is about 120° C., and it has a melting point of approximately 135° C. Courlene X.3. also shows less heat shrinkage than standard Courlene at comparable temperatures.

New Wing for Factory.—A new wing to the factory of Richard Klinger, Ltd., was inaugurated by the Minister of Supply, Mr. Reginald Maudling, and the Parliamentary Secretary to the Ministry of Health, Miss Pat Hornsby-Smith.

New American Standard for Reinforced Plastics Sheets.—A new standard to cover a reinforced plastic sheet laminate for mechanical and electrical applications has been adopted by the National Electrical Manufacturers Association, the American Society of Testing Materials and The Society of the Plastics Industry, Inc. Specified in this standard are control values for essential physical and electrical properties for a glass mat reinforced polyester plastic sheet laminate intended for use at elevated temperatures as required of Class B electrical insulation. This has been designated as a " general-purpose " grade with the thought that it may prove to be only the first of several grades since wide latitude in properties is attainable with the glass polyester materials.

Company News

British Geon Ltd. announce the completion of extensions to the Barry factory. It is anticipated that production of Geon p.v.c. will now reach 27,000 tons per annum.

Thomas De La Rue & Co. Ltd.—An Australian subsidiary company has been set up near Sydney to manufacture decorative laminated plastics. The new company will work in close association with Email Ltd. whose subsidiary James Balfour & Co., (Pty) Ltd., have acted as sales agents for " Formica " since 1947. It is expected to commence production within the next two years.

Monsanto Chemicals Ltd. announce that as from June 4, 1956, Monsanto Plastics Ltd. will be located at Monsanto House, 10–18 Victoria Street, London, S.W.1.

Jabroc Ltd. and Hydulignum-Jabroc (Tools) Ltd. announce that their telephone number is now Croydon 7187.

Firth Brown Tools Ltd. have changed the address of their Manchester Office to Speedicut House, Royle Street, Fallowfield, Manchester, 14.

The Telegraph Construction and Maintenance Co., Ltd.—The report of the directors and statement of accounts for the year ended December 31, 1955, show an increase in the trading surplus of the group of 56%; final dividend of 3¾% and a cash bonus of 1% has been recommended. Mr. J. N. Dean, chairman, in his report mentioned the plastics division of this group, which has an increased year's turnover of 20%.

Thos. Firth and John Brown, Ltd.—The Lancashire and North-Western Sales Office, hitherto in Manchester, has moved to 180–182 Sefton House, Exchange Buildings, Liverpool, 2. Telephone No. Central 7278/9.

T. H. and J. Daniels, Ltd., Lightpill Iron Works, Stroud, held their Open Day on Saturday, May 5. A display of transfer presses, injection moulding machines and extrusion equipment was arranged.

Fume Ducting.—Rediweld, Ltd., of Crawley, Sussex, are producing a complete range of standard polythene and p.v.c. tubes and ducts for the construction of duct lines for corrosive fumes. The parts are marketed under the trade name of Polynert.

George Cohen Sons and Co., Ltd., and **The Selson Machine Tool Co., Ltd.**, have been appointed joint sole distributors in the United Kingdom of the Carl Zeiss mechanical fine measuring tools.

Wild-Barfield Electric Furnaces Ltd. have transferred all the activities of their A.H.F. Induction Heating Division to Elecfurn Works, Watford By-Pass, Watford. Telephone number: Watford 6091.

B.I.P Chemicals Ltd.—The Resins Sales Department of B.I.P. Chemicals Ltd. has moved to Popes Lane, Oldbury, Birmingham. Telephone number: Broadwell 2061.

The British Xylonite Co. Ltd.—The final dividend for 1955 of 2½% on preference shares and 9% on ordinary stock has been recommended by the directors of this company. Group profit after deduction of tax for 1955 was £336,797.

Syntactic Foams.—Bakelite, Ltd., have published an advance information sheet on Syntactic Foams made from phenolic polyester, and epoxy resins.

British Oxygen Chemicals Limited announce that their polyvinyl acetate will in future be known as Vandike. The different emulsions will be labelled Vandike 500, Vandike 1,100, etc., indicating the specification to which the emulsion has been prepared.

Literature

Nylon for Extrusion.—A new I.C.I. booklet on the extrusion and properties of Maranyl nylon has been issued. Besides providing a complete list of the physical and chemical properties of nylon it also gives complete instructions on the best methods of extruding.

Vinyl Chloride Stabilizers.—Two technical bulletins from Pure Chemicals, Ltd., Kirkby Industrial Estate, Liverpool, give properties and details of Stanclere 10 and Ferroclere 1820 vinyl stabilizers.

Polyester Colour Pastes are the subject of a leaflet issued by Llewellyn Ryland, Ltd., Balsall Heath, Birmingham, 12.

Synthetic Fluids and Lubricants.—A new 52-page booklet on Ucon synthetic fluids and lubricants has been issued by Carbide and Carbon Chemicals Co., 30 East 42nd Street, New York 17, N.Y. The booklet covers properties, applications, and characteristics of these polyalkylene—glycol derivatives.

" Looking at Plastics " is the title of a book written by Mr. H. F. Whitmarsh, works director of J. F. Kenure, Ltd. The book has been produced to provide an insight into the injection moulding industry for its potential customers. Besides explaining the materials and their properties Mr. Whitmarsh also examines injection moulding machines, moulds and their design and costs.

Plastics in Catering The increasing use of plastics material in the catering trade is apparent from their extensive employment in two new restaurants opened at the Maison Lyons Corner House, Marble Arch. Both Formica and Warerite panels have been used for wall decoration and table tops and the upholstery of the arm chairs and banquettes is in candy stripe p.v.c. imported from Germany. In addition glass fibre reinforced polyester skillet holders are used extensively.

Dust and its Control.—A finely produced book on dust, its characteristics, problems and control has been issued by Sturtevant Engineering Co., Ltd., Southern House, Cannon Street, London, E.C.4. This company have had considerable experience in the manufacture of equipment for the control of air pollution and dust and have obviously made a close study of this subject.

Polythene-Coated Paper Sacks is the subject of some literature issued by William Palfrey, Ltd., Palfrey House, City Road, London, E.C.1.

Container Marking.—A guide to methods of marking containers of hazardous chemicals has been published by the Association of British Chemical Manufacturers. Copies can be obtained from the Association at Cecil Chambers, 86 Strand, London, W.C.2, price 7s. 6d. post free.

Plastics Pipe Tests.—The Society of the Plastics Industry, Inc., and the National Sanitation Foundation jointly announce an Identification Programme that will assure the public of a safe, uniform quality in plastics pipe identified by the Foundation for use in systems transporting drinking water.

The programme for applying the National Sanitation Foundation Seal of Approval to plastics pipe, thus identifying it for use in the drinking water field, is the result of a research programme of toxicity and taste studies which were made possible by the plastics industry starting more than three years ago.

The favourable report on the study should simplify the problem of offering the greatest possible protection to the health of the community without standing in the way of new developments which mean progress.

This study included twenty-two samples of plastics pipe to determine their suitability for underground use in conducting cold drinking water. The tests performed were designed to show whether or not any substance that might be deleterious to health would be extracted from plastics by an aggressive potable water, and if the passage of water through plastics pipe would affect the appearance, odour or taste of the water. The samples tested were classified broadly as polyethylene, polyvinyl chloride (including Saran), rubber modified polystyrene and cellulose acetate butyrate.

Thioglycollic Acid.—A new technical data sheet has been prepared by Robinson Brothers Ltd., Ryders Green, West Bromwich, on their thioglycollic (mercaptoacetic) acid. It is available in two strengths: 97–98% anhydrous and 75% aqueous solution.

Colour Pastes for Epoxy Resins.—The Claremont Pigment Dispersion Corporation, of New York, have prepared a range of colour pastes suitable for incorporation in epoxy resin compounds.

Suction Forming Equipment. — Borkland Laboratories, of Marion, Indiana, who claim to be among, if not *the* pioneers of vacuum forming, have prepared a brochure giving details of the type of machines which they now produce.

New Floor and Wall Tiles.—Following their recent introduction of Parquet floor tiles in thermoplastic, Marley are now making "Corquette", simulating the appearance of cork tiles in the same material. Four colours are available.

Added to the wall tile range, previously containing only pastel shades, are two new tiles in bold colours. These are Cherry Red, plain or with flashing, and Black with flashing.

Conferences

"Recent Advances in Catalytic Polymerization" will be the subject of a two-week Special Summer Programme to be given at the Massachusetts Institute of Technology from July 17 through July 27 during the 1956 Summer Session.

"This Programme," says Professor Ernest H. Huntress, Director of the M.I.T. Summer Session, "is directed to active and potential research workers in polymerization and allied fields of chemistry. It will present and discuss current knowledge of catalytic polymerization."

Full details and application blanks may be obtained from the Summer Session Office, Room 7–103, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

"Some Implications of Colour."—The Oil & Colour Chemists' Association will be holding a one-day symposium at University College, Gower Street, London, W.C.1, on Thursday, September 20, 1956, with the general title "Some Implications of Colour." Three papers will be given.

Full details will be sent to members of the Association individually at a later date, and non-members who wish to receive further information and application forms, when these are available, should write to the General Secretary, Mr. R. H. Hamblin, M.A., Oil & Colour Chemists' Association, Memorial Hall, Farringdon Street, London, E.C.4.

Annual Meeting.—The 75th annual meeting of the Society of Chemical Industry is being held on Tuesday, July 10. During the week of the meeting, July 9 to July 15, visits to a number of factories and research institutes have been arranged. The annual dinner will be held at the Dorchester Hotel on the Wednesday.

Colour Conference.—The British Colour Council exhibition "A Story in Colour" has been postponed until the week of September 24 when a conference on colour will also take place.

Personal

Mr. C. M. Hall has been promoted to Sales Manager of the Lactoid Division of B.X. Plastics Ltd.

Mr. H. R. Poole has joined the staff of Turner Brothers Asbestos Co. Ltd. as manager of their Plastics Department.

Mr. C. H. Waxman has joined Fibromold Ltd. and will be in charge of technical and production developments.

Mr. C. A. Barnes has been appointed Sales Manager of the Plastics Division of Pure Chemicals Ltd. **Mr. H. Verity Smith,** who previously combined the offices of technical and sales manager will now devote his whole time to research and development.

Dr. V. E. Yarsley last month celebrated his Silver Jubilee as a consultant chemist to the plastics industry.

Mr. D. R. Mackie has been appointed managing director of Monsanto Chemicals Ltd. Mr. Mackie has been acting managing director since November 1955.

Mr. L. W. Walker.—It is with regret that we announce the death of Mr. L. W. Walker of L. W. Walker and Company. Mr. Walker was vice-chairman of the North West Section of the Plastics Institute.

Mr. L. R. Armstrong has been appointed director of Catalin Ltd. Mr. Armstrong also holds the position of deputy chairman of British Cellophane Ltd.

Mr. A. P. L. Sullivan has accepted an appointment as Technical Consultant to the Plastidry Fire Hose Division of British Tyre & Rubber Co. Ltd.

Mr. C. F. Gysin has retired from the board of The Geigy Company Ltd. and **Mr. E. G. Turner** has succeeded him as director, and chairman. Simultaneously the following appointments have been made: **Mr. H. Clayton,** managing director, is now deputy chairman and managing director. **Mr. G. A. Campbell** and **Mr. H. Jones** are now joint assistant managing directors.

"Plastics in the Service of Man"

The following is a list of full names and addresses of companies mentioned in the illustrated feature, "Plastics in the Service of Man," which appears on pages 114 and 115 in this issue:—

65. Plastics at the Design Centre

Adrion Duckworth, 81 Stile Hall Gardens, London, W.4.
Arlington Plastics Development Ltd., Arlinghide Works, Eastern Industrial Estate, Harlow, Essex.
B.X. Plastics, Ltd., Higham Station Avenue, London, E.4.
Beetle—British Industrial Plastics Ltd., 1 Argyll Street, London, W.1.
Brookes & Adams Ltd., Barr St., Hockley, Birmingham 19.
E. K. Cole Ltd., Ekco Works, Southend-on-Sea, Essex.
Ferguson Radio Corpn. Ltd., 105 Judel St., London, W.C.1.
The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.
Greenwich Plastics Ltd., St. Mary Cray, Kent.
Halex Ltd., Higham's Park, London, E.4.
Imperial Chemical Industries Ltd., Newton Works, Hyde, Cheshire.
Lionide—Jas. Williamson & Son Ltd., Lune Mills, Lancaster, Lancs.
Morphy-Richards Ltd., St. Mary Cray, Kent.
N.B. Mouldings Ltd., Tavistock St., Dunstable, Beds.
Rotaflex (Great Britain) Ltd., 90 Regency St., London, S.W.1.
Rudic Products Ltd., Court Works, Church Rd., Caversham, Reading, Berks.
Rydura—Ryjack Productions Ltd., St. James's Buildings, Oxford St., Manchester, 1.
Storey Bros. & Co. Ltd., White Cross, Lancaster.
Thermo-Plastics Ltd., Luton Road Works, Dunstable, Beds.
Tygan—Fothergill & Harvey (Sales) Ltd., Harvester House, 37 Peter Street, Manchester 2.
Vent-Axia Ltd., 9 Victoria St., London, S.W.1.

Machines for the Industry

High-Speed Wire Covering Equipment

Now being produced in this country under licence from the American manufacturers, The Davis Standard Machinery Corp., the 3¼ in. extruder and high-speed wire covering equipment which we give details of here, has for several years been regarded with considerable favour by American cable manufacturers. Fawcett-Finney Ltd., who are the British licencees, are already well known in the plastics industry and it is with their co-operation that we are able to produce this article on this equipment.

MAKING its first appearance in this country at the Castle Bromwich B.I.F., as a British made product, the Davis-Standard 3¼ in. extruder complete with full equipment for the covering of wire with thermoplastics aroused considerable interest. The licencees for its manufacture, Fawcett-Finney Ltd., Berkley Street, Birmingham, 1, are well known in the plastics industry as the manufacturers of presses, accumulators and other equipment. They also enjoy a reputation as general engineers which is of the highest. It is with their kind permission and co-operation that we are able to give details and drawings here of the equipment and of the extruder itself.

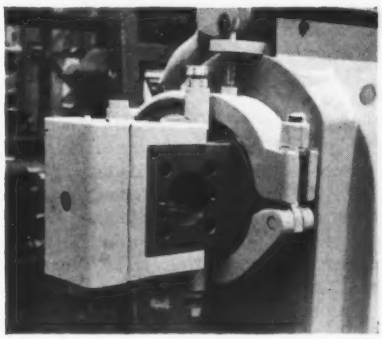
The Davis-Standard extruders have for the past eight years been building a reputation for reliability in the United States which today has made them virtually *the* extruder for wire covering. Such a reputation has been made on their rugged design and extremely high output figures as well as the high standard of quality which is an inherent part of their production. High output, and in this case figures of 220 lb. per hour and 160 lb. per hour for average grade p.v.c. and polythene respectively are not uncommon, demands take up equipment which must operate automatically at these high speeds. Such equipment is available and has been designed to operate at speeds in excess of 30,000 yds. per hour and reports indicate that 50,000 yds. per hour are possible. Here then is the complete wire covering assembly designed to work at speeds which ten years ago would have seemed improbable if not impossible.

The Extruder

Although at the moment the 3¼ in. thermoplastic extruder is the only one being made in this country it is anticipated that the full Davis-Standard range will soon be available. This range covers 1½ in. to 8½ in. thermoplastic extruders and also rubber extruders and continuous vulcanizing equipment built in 3¼ in., 4½ in. and 6 in. bore sizes.

Power for the extruder is supplied by a 30 h.p. Laurence Scott and Electromotors Ltd., variable speed A.C. motor which has a range of 125 to 2,000 r.p.m. The motor is mounted on a fabricated steel base the whole of which can be fitted on either side of the extruder according to customers' requirements. The drive is carried by roller bearings through a flexible coupling to a worm and gear reduction unit. The reduction afforded by this unit is 20½:1.

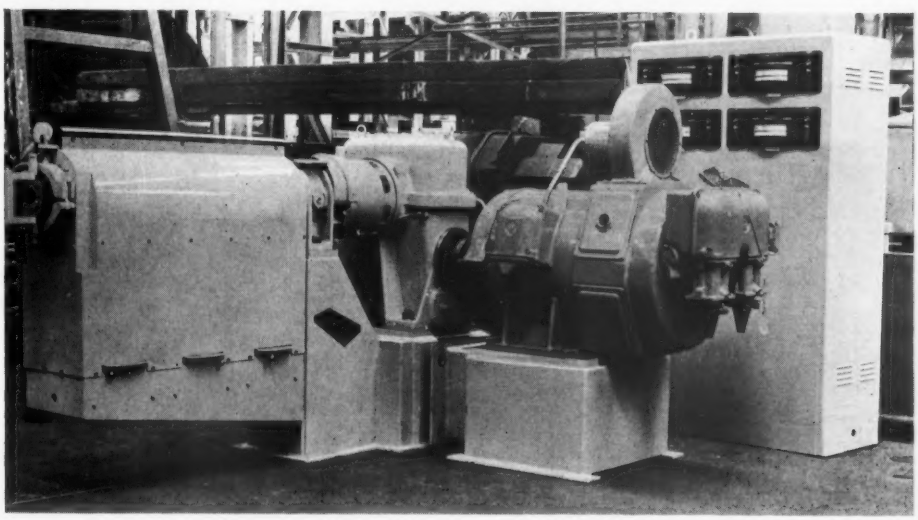
Lubrication of this unit is by splash lubrication in that the main gear picks up oil which is caught again by a catch basin and fed to the thrust bearing assembly by (10) before being returned to the sump where it is cooled and re-used. A flinger ring (6) is also fitted to the worm shaft.



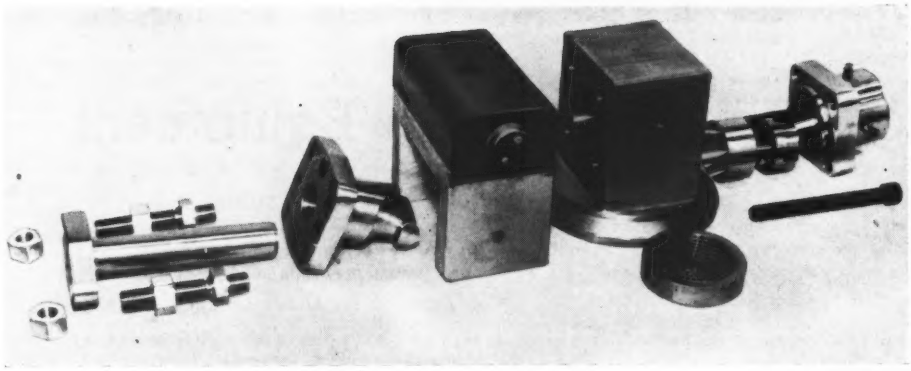
A close-up of the die clamping arrangement on the head of the extruder.

The hollow drive shaft is made from hardened steel supported at the back end by ball bearings. The main drive gear is keyed on to the shaft and at the front end, the cast steel thrust sleeve is also keyed on. The front of the shaft is also supported by ball bearings.

The thrust sleeve performs two important functions. It transmits the power from the motor to the extruder screw and takes up all the back thrust from the working of the material. By



The 3¼ in. Davis-Standard extruder now being manufactured under licence in this country by Fawcett-Finney Ltd.



The various components making up the wire covering die. The flow-feed of the material is directed by the component on the left next to the heater.

doing this the reduction gear unit is relieved of any thrust, thus reducing loss of power due to friction. The sleeve itself is made from cast steel and in accordance with the design practice on this machine is oversize for the job it has to do thus ensuring an adequate and indeed an almost excessive safety factor. The thrust is taken by extra heavy duty roller bearing (12) operating against a flange (13) on the sleeve itself. Radial bearings (15) also support the front end of the sleeve which is keyed on to the extruder screw. Lubrication is from the gearbox as previously described and the housing has an inspection plug and vent (14). Oil seals (16) are fitted at the rear of the feed throat.

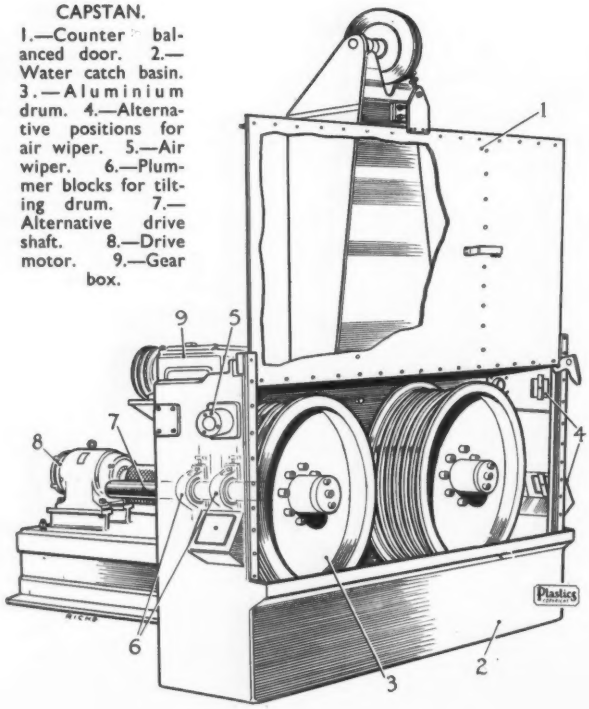
The extruder screw is of constant pitch with a 16:1 length to diameter ratio made from hardened alloy steel with a chrome plated mirror finish. The screw has specially hardened lands. Cooling is effected by standard practice through the centre of the screw from a rotating union (7) at the back end of the drive shaft. An Oilite bush is fitted at the rear of the feed throat. The raw material hopper (3) is of a large capacity and fabricated from stainless steel. The feed throat is water cooled through a side connection (17). Various types of screw with different compression ratios are available.

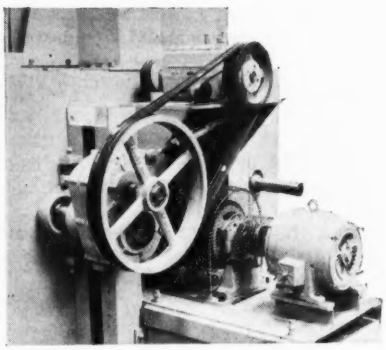
The barrel of the extruder is made up in three sections for convenience in servicing and has special liners (19) of Xalloy polished to a mirror finish which are removable, the barrel (18) itself being made from cast steel.

One of the most interesting points about this extruder is the heating unit. This is by the new Therma-fin heaters (20) for which patents are pending. These are made from cast aluminium into which tubular heaters are embedded. The heaters are made in pairs and are an interference fit on the barrel around which they are bolted. This type of heater-cooler unit has proved not only to be efficient but also to be virtually everlasting. Each heater unit has a thermo couple reaching to the barrel liner and is controlled by proportioning instruments (2). At high speeds it is often necessary to cool the barrel as the heat generated by working the raw material is in excess of that required. To compensate for this three axial cooling fans are fitted to the base of the barrel housing, these operated either automatically or by separate switches, project a cooling air stream around the fins of the heater and out through

CAPSTAN.

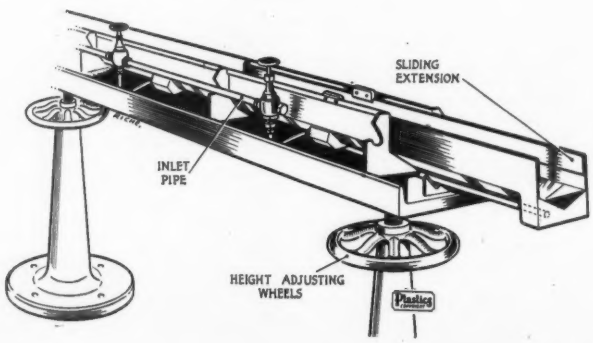
1.—Counter balanced door. 2.—Water catch basin. 3.—Aluminium drum. 4.—Alternative positions for air wiper. 5.—Air wiper. 6.—Plummer blocks for tilting drum. 7.—Alternative drive shaft. 8.—Drive motor. 9.—Gear box.





(Right) The driving mechanism for the capstan showing gear box and torque arm reducer.
(Left) The capstan and drive.

(Below) A section of the cooling trough showing the sliding extensions.



the top of the sandwich-type insulated casing, the amount of air being controlled by individual shutters (21) on the fans. This extruder is fitted with three barrel heaters and a breaker plate heater the latter being a smaller edition of the Therma-fin heater.

The head of the extruder has been designed for the quick fitting and removal of dies. Each die is held in a hinged die holder which is swung on to the head and locked in place by means of a hinged clamp type head closure (25). For removal or servicing it is only necessary to undo one bolt, operate the lifting cam (26) and swing the die clear.

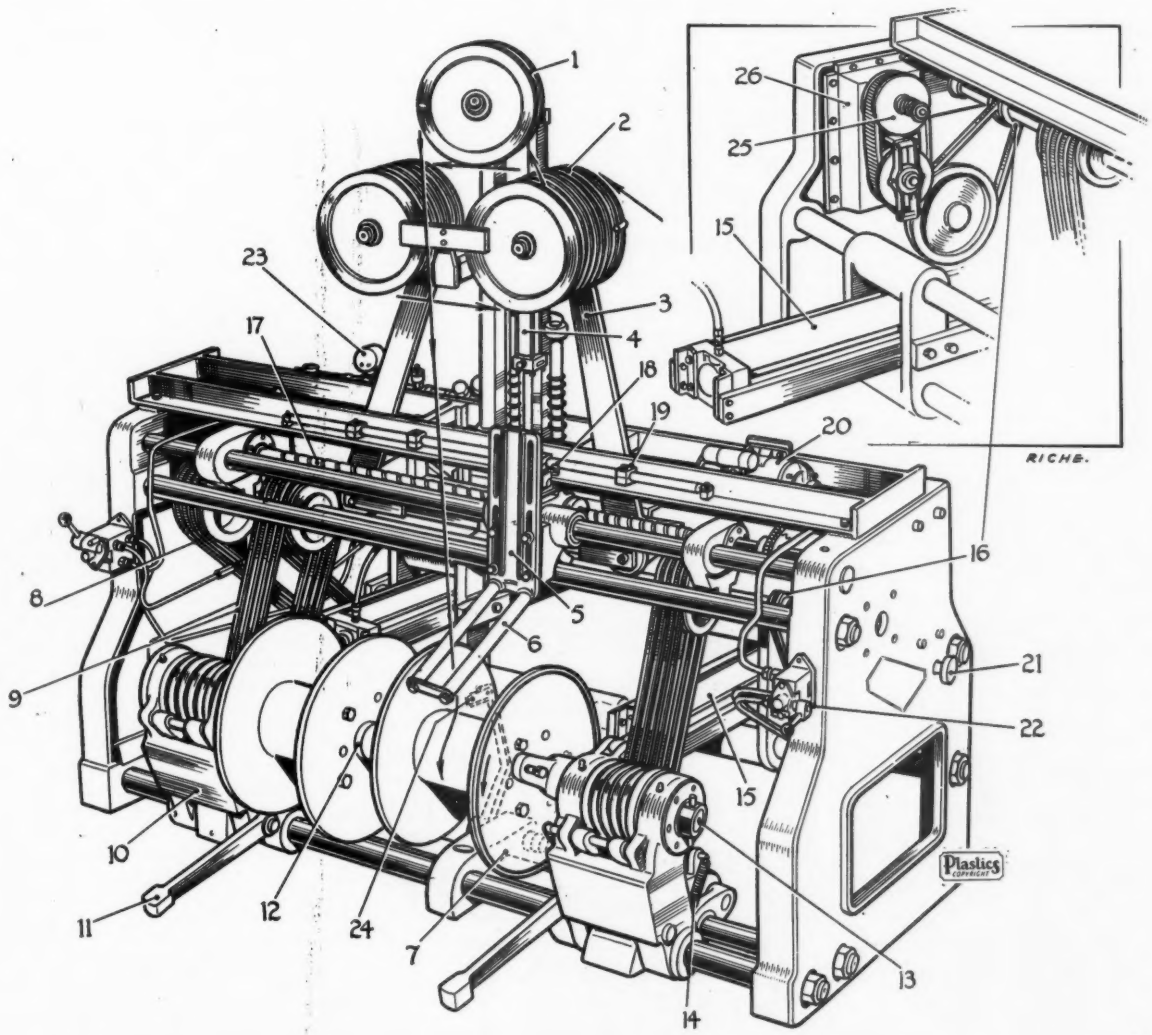
The die used for wire covering is shown in the accompanying illustration and has been designed to eliminate any "dead" spots where material can accumulate and decompose. It is fully adjustable for the centring of the insulation on the wire and controlling the thickness of the coating. The die heating is by controlled tubular heaters cast into an aluminium sheath.

Cooling Trough

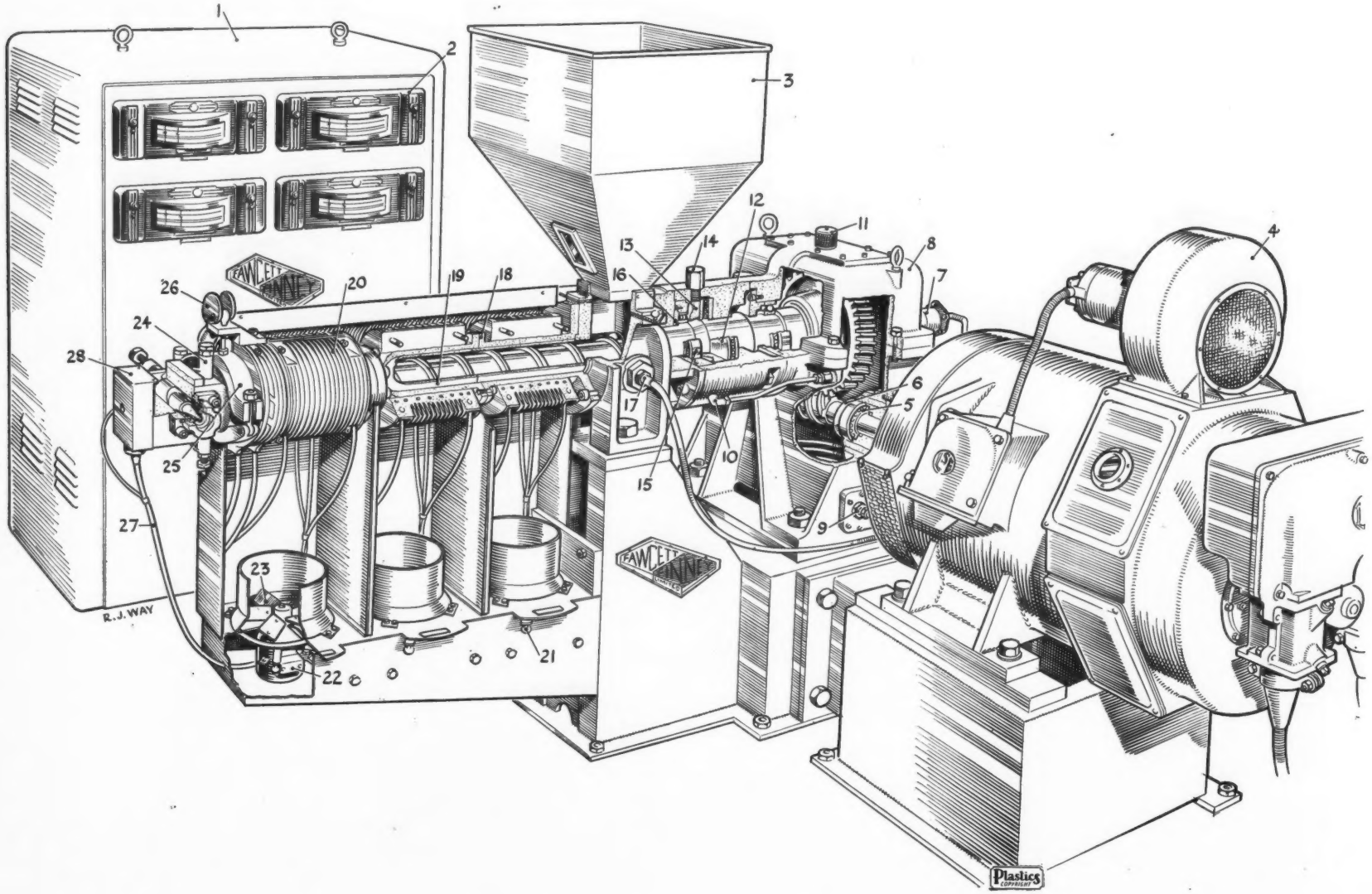
The water cooling troughs are made in 10 ft. sections, each section designed as a self-contained unit and for linking with adjoining sections. A sliding extension is fitted to enable the trough to be placed close to the die thus giving immediate cooling to the extruded product. The troughs are mounted on pedestals and their height is adjustable by means of a screw working inside the pedestal column. The trough is made from stainless steel and the water circulation is controlled by three cross valves feeding into each section.

Capstan

The capstan is connected directly to the cooling troughs and water from these flows into the capstan catch basin (2) and thus provides a considerable amount of additional cooling. As the speed at which the drums turn is considerable a counter-balanced door (1) is necessary to prevent splashing and also to act as a guard. There are several alternative positions for the wire entry port and corresponding positions for the air wiper assembly (5). The drive for the capstan is provided by a constant speed 5 h.p. electric motor (8) with a Heenan & Froude eddy-current coupling giving a $17\frac{1}{2}$: 1 speed range. By means of vee belts the power is transmitted to the gear box (9) which has four speeds with ratios of, 1:1, 1.6:1, 2.5:1 and 4:1. Vee belts couple the gearbox to a torque arm speed reducer which drives directly the cast aluminium capstan drums (3). Connected to the drive is an electric tachometer and indicator which controls the take-up



1.—Guide pulley. 2.—Dancer pulleys. 3.—Dancer arms. 4.—Wire tension air cylinder. 5.—Adjustable traverse guide carriage. 6.—Traverse guide rollers. 7.—Reel up drum. 8.—Main drive from motor. 9.—Double vee belt drive to reels. 10.—Reel arm, housing automatic brake. 11.—Spring loaded counter balance arm. 12.—Reel locking collar. 13.—Removable reel spindle. 14.—Tension spring for idler pulley. 15.—Air cylinder for lifting reels. 16.—Drive to gear box and variable speed unit. 17.—Traverse screw. 18.—Traverse relay switch. 19.—Traverse control stops. 20.—Quick traverse shift motor. 21.—Control knob for traverse. 22.—Reel lifting control valve. 23.—Air pressure gauge for reel cylinder. 24.—Knife. 25.—Variable speed unit. 26.—Gear box.



THE 3½ IN. DAVIS-STANDARD EXTRUDER

1.—Control panel. 2.—Proportioning temperature controllers. 3.—Stainless steel hopper. 4.—Motor fan. 5.—Radial and thrust ball bearing. 6.—Flinger ring for lubrication system. 7.—Screw cooling rotary union. 8.—Cast iron gear box. 9. Lubrication cooling coil connection. 10.—Lubricating connection to bearings from gear, oil-catcher. 11.—Oil filter and breathing cap. 12.—Roller thrust bearing. 13.—Thrust sleeve flange. 14.—Lubrication inspection and breather cap. 15.—Radial bearing. 16.—Oil seal. 17.—Inlet for water, cooling feed throat. 18.—Cast steel barrel. 19.—Barrel liner. 20.—Therma-fin heaters. 21.—Air damper control handle. 22.—Cooling fan motor. 23.—Axial cooling fan. 24.—Hinged die holder. 25.—Die clamp. 26.—Lifting cam for clamp. 27.—Die heater and thermo-couple lead. 28.—Wire covering die.

equipment speed. The two drums are mounted on Plummer blocks which enable them to be tilted thus preventing any fleeting, rubbing or over-running when thin wire is being covered. Drum sizes can be varied to suit requirements up to a maximum size of 48 in. diameter. Additional equipment not shown on the drawing which can be fitted is a tractor unit.

Wire Measuring Machine

The measuring machine will handle wire and cables up to 3 in. in diameter at speeds of up to 50,000 yds. per hour with an error of less than 0.1%. The wire is guided through two cast aluminium wheels surfaced with molybdenum which record the total ouput. A pre-set measuring device is also incorporated whereby at set lengths a signal can be sent to the take up equipment and winding taken up on a new drum. This measuring device is continuous and does not need re-setting after each cycle.

Dual Take-up Equipment

Wire covering at the high speeds mentioned previously has made necessary a very efficient take-up system; one which is continuous and which must change reels automatically with no delay and consequent build up of wire. The dual take-up which we illustrate is such a machine.

The wire passes round the two dancer pulleys (2) and over the guide pulley (1). From the pulleys it is fed between the traverse guide rollers (6) on to the reel (7). The main drive is by a constant speed motor through a Heenan Froude coupling which gives a variable speed of from 0 to 1,400 r.p.m. and from thence to a four speed gear box (26) and then by vee belts (8) to the reel driving shaft. From this shaft, double vee belts (9) are held up to the reel driving pulley by an idler pulley held by a tension spring (14). The reel driving shaft also operates the traverse mechanism by a variable speed unit (25) which can be manually controlled to vary the width of lay. Two electro-magnetic, counter-rotating clutches actuate the traverse reversal movement, each clutch being engaged and dis-engaged by a relay switch (18) worked by the two stops (19). The speed of the take-up drive is governed by the tachometer on the capstan.

When the reel is nearing completion the dancer arms approach the vertical position. Their function is to maintain an even tension on the wire despite the varying diameter of the reel and this is done by means of an air cylinder (4) and bleed valve which can be set to give any tension between 3 and 10 lb. Also at this time the knife (24) which normally remains between the drums moves back and clear of them. When the measuring machine gives the signal that the pre-set footage is on the reel both magnetic clutches disengage from operating the traverse screw (17) and the quick traverse motor comes into operation moving the traverse guide across to the empty reel and reversing quickly to nip the wire on the drum before resuming its normal movements. The difference in diameter of a full and empty barrel necessitates an increase in the reel speed and the taking up of the slack until this becomes effective. This is done by the dancer arms which open up and actuate a transducer which increases the drive speed. After a short interval the knife moves forward and cuts the wire linking the two reels. The reel lifting air cylinder then pushes the reel arm (10) away from the drive and operates a brake on the reel spindle. The reel is lowered to the ground and the spindle removed and an empty reel put into position.

Take up equipment is also available for 72 in. reels and 36 in. diameter by 25 in. wide reels. The whole system is adjustable to take wires with up to ½ in. o.d. and can run at an infinite variety of speeds.

Pay-off Equipment

The wire pay-off equipment has been designed to continuously feed wire from the reel to the extruder at a constant tension. The reels are handled and lifted by means of an air cylinder and the wire is fed over a sheave on a pivoted tension arm which works the brake on the reel spindle, thus giving a constant tension. Equipment is available to handle 72 in. diameter reels weighing up to five tons.

We wish to acknowledge with grateful thanks the assistance and facilities put at our disposal by Fawcett Finney & Co. Ltd., and for the valuable advice and knowledge which their staff have supplied in the compiling of this article.

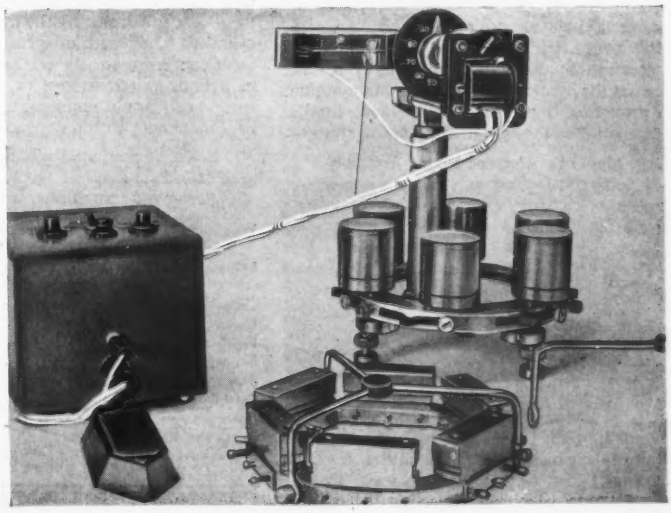
MEASURING SURFACE ADHESION OF FOILS

THIS recently developed apparatus, brought out by Karl Frank, G.m.b.H., Weinheim-Birkenau, Western Germany, serves for the measurement of surface adhesion of foils of all kinds. It consists of three parts: a base-ring with torsion, or spring balance, a stretching-ring for thin foils and a holding-ring for thicker foils, synthetic leather, and other materials.

A base-ring with levels and three adjustable feet supports a pillar, which by means of a screw or cog-gear is adjustable in height and carries an interchangeable spring or torsion weight with scale, indicator and power arm. Thin foils are measured with the stretching-ring, which is arranged for six tests.

With a stamping measurer, test pieces are stamped out and folded, stretched with the clamp on the folding place, laid over the place on which the adhesive power is measured, and held firmly with the broad end in the clamp, whereby the pointed end with the hole remains free. After a paper strip has been placed above the measurement place, the pre-loading weight and then the weight, whose size can be determined through the test conditions, are placed on. In the same way the remaining five clamping contrivances are loaded with foils. The ring prepared in this way can now be placed according to test conditions in a warming or cooling cabinet. After expiration of the testing time the weights are removed, the ring placed on the base-ring and the free end of a sample hung in the hook, and set up through height adjustment, whereby no tension may arise, which is shown through the indicator.

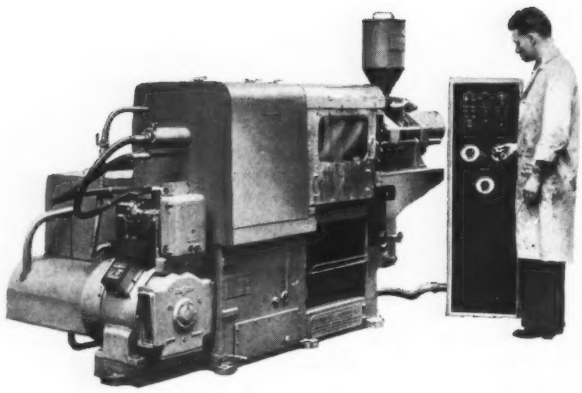
After careful removal of the pre-load weight and of the paper strip a continually growing power is carried over on to the free end of the test through turning a button over the spring or torsion weight, calibrated in a power unit. The button, with indicator, is turned until the cleavage of the surface on the measurement place is shown on the indicator through rising above the marking stroke. By reading off the indicator position on the scale the adhesive power in the calibrated unit can be determined.



Machines for the Industry

New Peco 2oz. Injection Machine

The latest in the Peco series of injection moulders represents one of the most advanced pieces of equipment of its kind in production. The salient features are reported here.



(Left) General view of new machine.

Constructional Features

THE requirement of automatic production has stimulated the development of a new concept in the design of this new injection moulding machine manufactured by the Projectile and Engineering Co. Ltd. Factors which hitherto have had little influence in the function and operation of injection moulding machines are now most important to successful continuous automatic production.

The Peco Model 20M.S. 20 has been specifically designed to meet the stringent demands of automation—these being broadly, high productivity, continuous trouble-free operation, reduced labour costs, and, most important from the injection moulding viewpoint, the maintenance of the highest standard of quality throughout the production run.

Materials and Manufacture

As in the case of its predecessors in the Peco range of injection moulding machines, the materials selected for its manufacture and the machinery employed in its production are of the highest order, commensurate with the stringent demands of the very exacting works inspection to which the machine is subjected. Upon completion of assembly all machines undergo a series of performance tests before being released to the customer, thus ensuring the reliable performance expected from high quality automatic production machines.

The Machine Base

The main base is fabricated from heavy gauge steel plate and is of welded construction. This gives a rigid support to the die locking and injection unit assemblies, and at the same time, houses the hydraulic oil reservoir. In addition, a mounting is provided on the base for the installation of the hydraulic control equipment.

Mould Locking and Platen Assembly

The mould locking movement is carried out by a fully-balanced, quick-acting toggle mechanism which is fitted with hardened and ground toggle pins and bushes. The ample dimensions of these pins ensure reduced stress over the projected bearing area, ensuring long life and minimum wear. Die height adjustment is effected by the rotation of nuts fitted on either side of the main toggle thrust plate. The moving platen, the stationary platen bolster, and the thrust plate are cut and machined from solid rolled steel plate, thus avoiding the possibility of porosity and distortion which may be manifest in steel castings. The stationary platen itself, that is, the plate to which the injection half of the mould is fixed, is a " floating " member, being guided as is the moving platen, on long phosphor bronze bushes located on the tie bars. By this means, accurate location of the two mould halves is assured, and at the same time, due to the low bearing load, wear is reduced to a minimum. Each platen is amply proportioned in order to avoid undue deflection, and to ensure perfect alignment of the mould faces.

The ejection system with which this machine is equipped is extremely versatile, permitting central ejection to be used and/or ejection at various points over the platen area. This is a great advantage in as much as the mould ejector plate can be confined in size, allowing adequate support for the tool to be provided.

Injection and Heating Unit

The injection unit comprises a cradle which is supported on two slide bars. The whole unit is retractable both for a sprue breaking movement and for cleaning purposes. Movement is effected by a hydraulic cylinder. This cylinder holds the nozzle under controlled pressure against the sprue brush, eliminating any possibility of nozzle " hobbing ", and control is so arranged that the withdrawal stroke may be varied according to requirements. If a short sprue breaking stroke is being used on automatic or semi-automatic cycle, this may be over-ridden for cleaning purposes by the depression of a push button. Adjustment of the nozzle to the sprue brush is fully automatic, this being performed by the hydraulic carriage cylinder. The length of sprue breaking movement can be very easily set by the adjustment of a limit switch striker, or, alternatively, if sprue break is not required, the nozzle can be kept in contact with the sprue bush.

The plasticizing unit, the basic design of which has proved so successful on other Peco injection moulding machines, is supported in the main cradle. It is heated by resistance band heaters clamped to its external surface and its temperature is controlled in two zones by indicating controlling thermometers. The plastics material feed device is of the fully self-compensating type and is designed for easy adjustment. The feed mechanism is operated by the main injection ram through a shear pin safety device which protects the unit from excess load should this movement be obstructed for any reason. Arrangements are made in the feed cylinder so that a " weir " can be fitted to prevent the over-spill of externally lubricated or spheroidal materials.

Hydraulic Control

The complete hydraulic control gear, except for the pumps, is mounted at the rear of the machine. All valves are of the " manifold mounted " type and are easily accessible, thus providing extremely easy maintenance. Hydraulic power is generated by two pumps, which, combined, give a very large delivery. The pump capacities are arranged so that during holding periods when a large volume of oil is not required, most of the delivery is diverted to tank, thus reducing the power requirements of the machine and any tendency for the machine to over-heat.

Electrical Control

The complete electrical control equipment, except for the operating push buttons, is mounted in a cabinet which is remote from the machine. This cabinet may be placed in any position and all machine settings may be locked.

TABLE I—INJECTION DETAILS

	ENGLISH	METRIC
Weight moulded per shot (Polystyrene)—Single Feed	1.5 oz.	42.5 gr.
Double Feed	2.0 oz.	56.7 gr.
Volume moulded per shot (Polystyrene)—Single Feed	2.46 in.³	40.3 cm.³
Double Feed	3.28 in.³	53.7 cm.³
Capacity of Feed hopper (Polystyrene)	30 lb.	13.6 kg.
Hopper Feed displacement— Single Feed	11.4 in.³	187 cm.³
Plasticizing capacity *	35 lb./hr.	16 kg./hr.
Diameter of injection plunger	1.37 in.	34.9 mm.
Area of injection plunger	1.48 in.²	9.5 cm.²
Total force on injection plunger	23.760 lb.	10.775 kg.
Maximum pressure on material	16.000 lb./in.²	1125 kg./cm.²
Full stroke of injection plunger	6.5 in.	165 mm.
Rate of injection	6.5 in.³/sec.	107 cm.³/sec.

*Dependent upon material and mould construction.

Machine Operation Sequence Control

Machine operation is, of course, fully-automatic, but in order to increase its versatility, arrangements have been made for either semi-automatic or manual control, the rotation of a master switch being necessary for selection of each.

Fully-Automatic Operation

To protect the mould from damage, a very sensitive safety device has been incorporated, the use of which ensures that at no time can the platens close under high pressure if there is any foreign body between the die faces. The sequence of operation is as follows: To commence, a push button is depressed. The moving platen then moves forward at high speed until the mould faces are just about to contact. At this point the platen decelerates until the mould faces are in contact.

This slow speed movement is provided in order to eliminate damage due to hammering of the die surfaces, especially if flash or other inclusions are present. When the mould faces are in intimate contact with one another, the closing movement reverts to high speed to complete mould locking. Should, however, a moulding fail to eject, or the mating mould faces fail to contact for some reason, the machine will open and be rendered totally inoperative. No damage can be done to the moulds, due to the fact that the "floating" platen previously mentioned will not have come into contact with its bolster before the machine has reversed, and, therefore, no pressure can have been exerted on the mould. When the mould is fully closed a limit switch is depressed which selects the injection ram forward, the injection, boost and cure periods being controlled by process timers. The injection timer controls the "plunger dwell" period, the boost timer controls the period of maximum oil delivery to ensure a high constant rate of injection, and the cure timer governs the period between initial retraction of the injection ram and the opening of the mould. This series of operations will repeat automatically unless the machine "senses" some inclusion between the mould faces.

Semi-automatic Operation

Semi-automatic control of the machine is selected by rotation of a switch. By this system of control, it is only necessary for the operator to depress a push button to initiate each successive machine cycle, each individual cycle being entirely automatic. Thus, the injection, boost and cure periods and the opening of the mould for ejection are carried out automatically.

Automatic Double Feed

To ensure the highest possible speed of operation, an automatic double feed device has been fitted. This is only necessary for shots in excess of 1½ oz. and is selected by a rotary switch. The double feed movement is very fast and, like plunger pre-advance, takes place during the cure period. With double feed, shots of up to 2 oz. of polystyrene can be obtained.

Plunger Pre-advance

A system of pre-advancement of the injection plunger during the cure period has been incorporated. This device provides a considerable saving in cycle time, especially under fully-automatic operation. After the injection timer has finished its run the injection ram moves fully back and then advances to a predetermined position. Thus, that part of the stroke which is not used for actual injection is carried out during the cure period. Should the cure timer be set for a period less than is required for this additional movement, the mould will not open until it is complete.

TABLE 2—MOULD LOCKING DETAILS

	ENGLISH	METRIC
Size of platens	17 in. × 17 in.	432 mm. × 432 mm.
Space between tie bars (see 10.25 in. × 10.25 in. platen details)		260 mm. × 260 mm.
Mould opening stroke	7.75 in.	197 mm.
Maximum mould height	13 in.	330 mm.
Minimum mould height	5 in.	127 mm.
Mould locking force—English tons	70	
U.S. tons	78	71T.
Projected moulding area*	37 in.²	238 cm.²

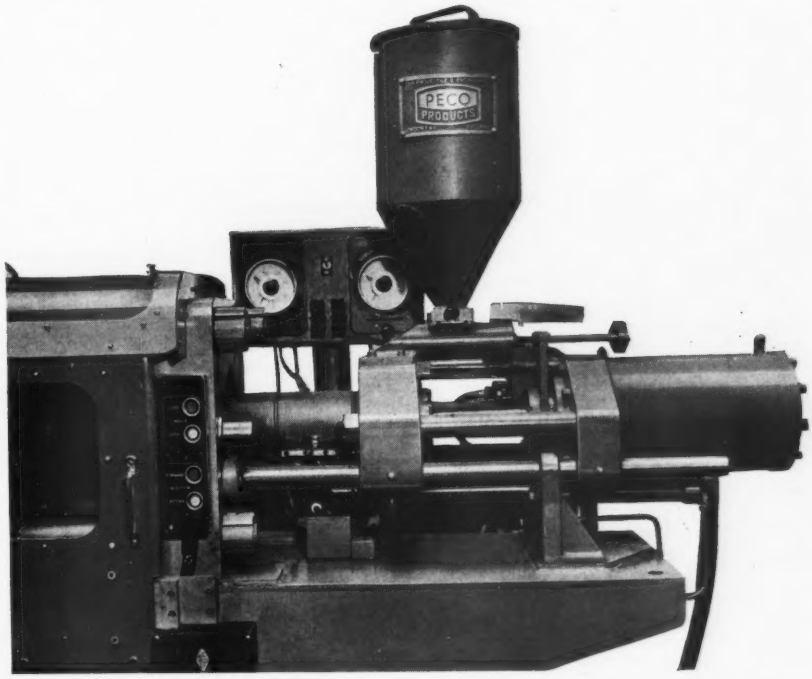
*Dependent upon material and mould construction.

Plunger Stroke Adjustment

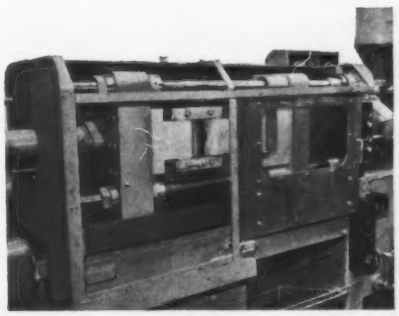
In order to reduce cycle time when shots below the rated capacity of the machine are being produced, the injection plunger stroke may be shortened to eliminate unnecessary movement.

Safety Gate

A fully interlocked safety gate is provided which even when very slightly opened immediately arrests all movements of the machine, thus ensuring complete safety.



(Above) The hopper and plunger mechanism in detail. Controls are shown on the left.



(Above) Toggle mechanism at rear end of machine.

TABLE 3—GENERAL DETAILS

	ENGLISH	METRIC
Minimum dry cycle time—Single Feed	4 secs.	4 secs.
Double Feed	6 secs.	6 secs.
Power consumption of heaters at full load	5 kw.	5 kw.
Motor size	10 h.p.	10 h.p.
Capacity of oil reservoir—Imp. gall.	40	
U.S. gall.	48	182 litre
Weight (dry tank)—English tons	2	2.0°T.
U.S. tons	2.24	

TALKING SHOP . . .

London Section A.G.M. The last technical meeting of the session was held at the Wellcome Foundation on April 26. The paper was presented by Mr. J. H. Bennitt of Bakelite, and is reported elsewhere in this issue. Prior to the lecture the section held its Annual General Meeting. The officers and committee for the coming year are as follows:—Chairman, Phillip Morgan; Vice-Chairman, C. W. Welch; Hon. Secretary, C. W. Oakhill; Committee, T. C. Corbett, past chairman, C. L. Child, D. S. Mahon, A. B. Merriam, J. W. Moore, E. S. Narracott, C. A. Redfarn, W. C. Wallis, J. D. Winston.

London Section membership is now over 1,000, and at the A.G.M., tribute was paid to Mr. Corbett for his work for the Institute in his year of office as chairman. 1955/56 was an outstanding year for the London Section, and its success was largely due to his efforts.

* * *

Araldite Coating Saves Dead Sea Scrolls. Following upon Professor H. Wright Baker's remarkable engineering success in opening the famous pair of bronze Dead Sea Scrolls, much interest has centred on the methods he used, and press reports have mentioned the key part played by an "aircraft-type glue." It is now learned that this was one of the Araldite range of epoxy resins manufactured by Aero Research Ltd., of Duxford, Cambridge, and that a coating of Araldite saved the decomposed bronze from disintegration upon being cut open.

Descriptions of the extent to which the metal had deteriorated, during its life of some 2,000 years, constitute a remarkable tribute to the coating properties of epoxy resins. The scrolls were curled up like a Swiss sandwich roll. They were completely oxidised and extremely fragile—"far more brittle than glass." Stone dust had filled the folds. Corrosion and other products had bonded surfaces that had been in close contact. Any attempt to unroll the bronze would have destroyed the scrolls.

Complex problems of decomposition, fragility, adhesions and infiltration of dust also ruled out reduction of the copper and other salts by metallurgical means. Cutting the bronze into strips was the only remaining possibility, but this course posed the problem of sufficiently reinforcing the near-crumbling metal to withstand sawing and handling.

Professor Wright Baker, at the Manchester College of Technology, used a transparent reinforcing coat of Araldite resin—so successfully that he has placed in the hands of the Jordan authorities an almost complete transcription of the writings prepared from the sawn-off sections of the scrolls.

The nature of the contents of the bronze scrolls will not be known until the international team of scholars which is at work on the script in Jordan has prepared its report. The scrolls are obviously associated with the library and domestic records of the religious order of the Essenes, of about 2,000 years ago, and a knowledge of their contents is awaited by archæologists and biblical scholars with great interest.

* * *

Electro-deposition Mould-making. Many years ago this paper described work done by the London and Scandinavian Metallurgical Company in the manufacture of moulds by electro-deposition. A few days ago we saw the company's new plant at Wimbledon, where eventually nearly 100 people will be employed. Mr. Spiro, the tool division manager, is justifiably proud of the new factory, only just completed and decorated in the contemporary pattern.

The company's process, which is licensed in five countries overseas, is developing rapidly; injection moulds, slush moulds and blow moulds are specially noteworthy. Now a well-tried process, it takes its place with established mould-making techniques.

* * *

Institute Annual Lunch. Is it a straw in the wind that the Institute's guest speaker at the annual luncheon on July 3 is to be Lord Baillieu, chairman of the Dunlop Rubber Company ? For some months rumours have been current in the industry of a link-up between the Institution of the Rubber Industry and the Plastics Institute. Lord Baillieu has played a prominent part in the research and educational spheres of the rubber industry. Born in Australia in 1889, he was created a Baron in 1953.

At all events, the lunch should be interesting. Application for tickets should be made to the Institute secretary, Mr. N. Griggs, at Mandeville Place. It will be held at the Dorchester Hotel.

* * *

Nuclear Energy and Plastics. Elsewhere in this issue are three articles dealing with radiation. One has been contributed by Dr. R. Roberts, of Harwell. There he heads the department dealing with plastics. Another has been written by Dr. N. H. Langton, one-time boffin with the R.A.F., and now on the staff of the National College of Rubber Technology, where he is in charge of the physics laboratory. Dr. Roberts has reviewed the whole field of radiation as it may affect the plastics industry, and has given a valuable lead as to future possible developments. Dr. Langton's article is specific in that it deals with the influence of ultra-sonic radiation on Perspex. His photographs, taken with the electron microscope, and his account of the experimental procedure, give some indication of the fine limits to which scientists can now work.

* * *

Benevolent Fund. Perhaps the Welfare State has had something to do with the decline of the old habit of forking out, as generously as one's purse would permit, for charitable funds and societies. We have so many pension schemes, private and State, that many of us forget the unfortunate who, when he retires, goes to "live" on the old age pension. Our industry seems to have an unusually high percentage of companies offering no pension scheme to their salaried staffs. And those that do frequently make no provision for a widow.

M. P. Macfarlane, chairman of the Institute Benevolent Fund appeals for donations. I gather, and I am not surprised, that the Fund is in pretty low water. Last year donations amounted to £200. For the statistical, this is just over 1s. a year per member of the Institute. Let's make it 2s. this year. You can send your money to the Institute's address by adding a small sum to your annual subscription.

This is a very worthy cause, and many do not realise that apart from the actual financial help given, the Trustees of the Fund contact the widows of deceased members of the Institute; and that can be a great comfort to a woman in such unhappy circumstances.

* * *

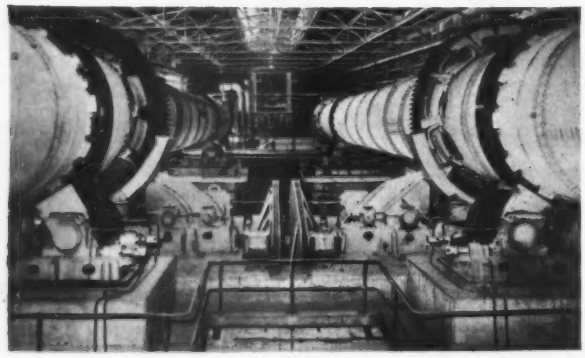
Tents for Telephone Men. One of the most familiar sights to the city dweller is the curious tent erected by G.P.O. workers to hide from the public gaze the mystical brewing of lead potions, apparently necessary to keep the telephone service in working order. They are also used, I suspect, as convenient hidy-holes to brew tea and perhaps also to cover a swift game of pontoon.

I have always been impressed by the speed with which the little tents are erected and have wondered whether perhaps other workers, such as the little man who vanishes down a manhole (drains ?) have felt jealous of this stylish method of keeping out the rain and the vulgar stares of onlookers. If so jealousy is about to take an upward surge since Cascelloid Ltd. have now introduced a glass-reinforced plastics structure, collapsible, and which is translucent. The precise goings on inside the tent will still be wropt in mystery, but the linesman will be able to work without the use of a lamp.

* * *

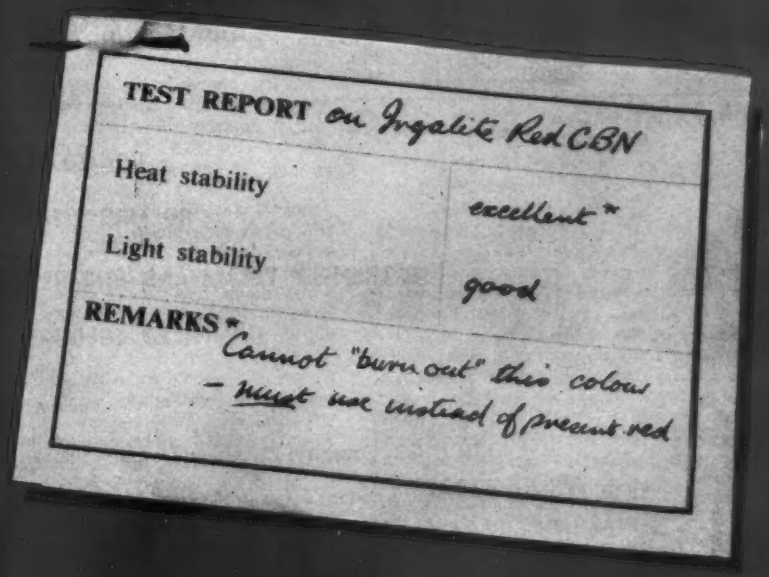
The Titanium Pigment Story. Went to see the other day a most impressive film by British Titan Products Co. Ltd., describing the discovery, the industrial development and the commercial applications of a new element. Filmed in Eastman Colour, this ranks as one of the best industrial films I have seen for a long time and will be of special interest to the plastics industry, showing as it does the use of this white pigment in material manufacture.

PLASTIKON.



Titanium pigment is dried in these huge rotary furnaces. See "The Titanium Pigment Story."

Colours for Polystyrene



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P(2)-3

High Molecular-Weight Nylon

Part I. Comparison with other polyamide materials

By W. STINER*

This paper was first read at the 1955 Congress of the Swedish Plastics Federation. The author discusses the Grilon nylon materials, with special reference to extrusion and the manufacture of foils.

Introduction

WHEN polyethylene made its entry into the plastic industry, it gave an unexpected fillip to machinery design and to fabrication and processing techniques. This very versatile plastic material possessed properties which made it extremely desirable for it to be made up into foil, despite the fact that the methods hitherto used for foil production—the extrusion of foils on calenders—were not practicable with this new material. So much progress has been made in extrusion technique that there are entirely new processes available today, such as the blowing technique. It is well known that this method is economical and the capital investment involved is very much lower than that of the calendering process.

For the production of thicker foils the " wide slit " nozzle method has been evolved. By this means it is possible to produce flat sheets from thermoplastic materials having melts of widely varying viscosities.

The introduction of polyethylene has also led to the large-scale manufacture of bottles from plastic materials. The many and varied advantages offered by polyethylene both as regards processing and fabrication technique have meant an undreamt-of impetus to the plastic industry as a whole but it must nonetheless be borne in mind that even polyethylene is subject to the law which is paramount throughout the world of plastics, viz.: there is no all-purpose material.

Every new plastic that comes along opens up new fields of application. It complements the other existing materials and so widens the general scope of the industry as a whole. Thanks to the unremitting publicity by producers and processers of plastic materials, the time is now past when plastics were regarded purely and simply as mere substitute materials. Nevertheless only within the confined circles of the industry itself is it realized that there does not in fact exist a universal plastic material which will satisfy all requirements, whether connected with the actual processing of the product or its finished application.

Plastics today are no longer mere substitutes for the natural raw materials, but in like manner, every plastic material may be regarded as a complementary product to every other member of the immense range of plastic materials to be found in the world today.

The questions outlined in the pages which follow in regard to high-molecular Grilon products can only be discussed in this period of the development of polyethylene, because if it had not been for the detailed experimental activity in this field, the processing techniques for polyamide foils, bottles and tubes would not be known.

For instance, if we compare the polyamide plastics with polyethylene we find a striking similarity on one important point: it is impossible to extrude sheets by the calendering method on a sound commercial basis.

From the standpoint of the purposes for which it can be used, polyamides are interesting complementary products to polyethylene and other plastic foils and semi-finished products.

* Holzverzuckerungs-A.G., Zurich.

High-molecular Grilon Products Compared With Other Polyamide Types

When manufacturing foils, bottles and pipes by extrusion method, the polyamides show two particular features which result from their partially crystalline structure:—

(1) Their very sharp melting point, and consequential narrow softening range.
(2) The low viscosity of the melt.

Whilst, on the one hand, it is the sharpness of the melting point which is responsible for the fact that nylon does not lend itself satisfactorily to calendering under heat and pressure, it is on the other hand the fluidity of the melt which is to blame for the considerable technical difficulties which arise in connection with extrusion.

These two factors together have the effect of rendering any process of fabrication starting from the melt extremely difficult. After the mass has been shaped at the nozzle, it sags together under its own weight.

It is not possible to subject the formed profile to a subsequent calibration, because as soon as it reaches the solidification point the material becomes completely rigid. At temperatures below its melting point, the viscosity is so high that it is no longer possible for shaping to be carried out on a practical scale, yet within just a few degrees of the melting point the material becomes so fluid that it flows like warm honey.

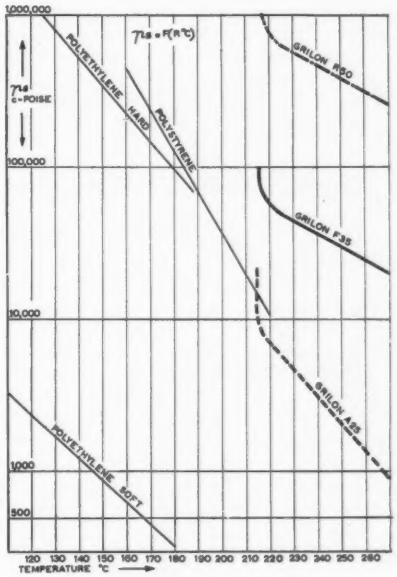
The actual melting range is not defined with equal sharpness in the case of all types of polyamide. Nylon 6,6 polymers have the narrowest range. In the case of nylon 6 polymers, on the other hand, that is to say those on a caprolactam basis like Perlon, Akulon and Grilon, it is not quite so sharply defined, although even here it still keeps within + 5° C. of the actual melting point of 215° C.

The only means of obtaining a wider melting range in polyamides is by making co-polymers, for instance the polymerization of AH salt with caprolactam. In this manner, if proportions of 80–60% : : 20–40% are employed, it is possible to extend the melting range to about 20° C.

The fact of having co-polymers, however, inevitably leads to major changes in the chemical properties of the material. In other words, there is an appreciable increase in the swelling capacity of the polyamide and at the same time an increase in its flexibility, although this is accompanied by a decrease in its strength.

Above the melting point, the viscosity of nylon is not affected greatly by the temperature. The viscosity decreases slowly right up to the decomposition temperature. Here again, this latter temperature is less sharply defined in the case of the nylon 6 type than in that of the nylon 6,6 type. The decomposition temperature of nylon 6—providing atmospheric oxygen is excluded—is somewhere in the region of 300° C. For this reason it is possible to process nylon 6 on screw type presses in the temperature range from 220–300° C. If we plot the viscosity curve of Grilon against the temperature, for temperatures above the melting point, this shows very clearly the difficulties which are encountered in processing normal polyamide polymers.

The fact that the viscosity of the material at melt, which is in itself very fluid, is so little dependent upon the temperature has the effect that even if the working temperature range is wider, as may be the case with caprolactam polymers, there is still very little room for shaping a profile after it has once been made. The characteristic intermediate " plastic " stage, such as is found with the thermoplastic materials of the conventional type, is practically non-existent.



Melting viscosity of various thermoplastics.

If we now compare the way in which the viscosity of various thermoplastic masses varies with the temperature, as shown in Graph 1, we can obtain a very clear picture of the special position occupied by nylon 6 normal polymer in relation to the conventional plastic raw materials, such as polystyrene and p.v.c.

The present-day machines which are known as nylon extruders go a long way towards meeting these difficulties. By the use of a suitable type of screw the fluid mass is subjected to a sufficient degree of compression whereby a pressure build-up is produced, so that the material is fed uniformly to the nozzle; in other words there is no " pumping effect."

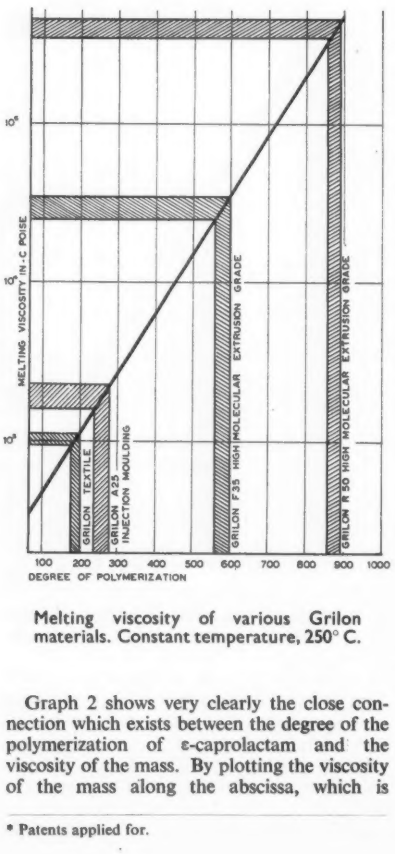
The length of the screw has been increased,

thus increasing the heating area, so as to be able to cater adequately for the high melting point. There has been a considerable improvement in temperature control techniques, and nowadays by employing thermo-couples or electronic temperature controllers it is possible even with machines of quite ordinary design to maintain the temperature constant to within + 2° C. The adoption of these various contrivances has resulted in many fabricators being able to achieve much greater constancy of performance in processing polyamides possessing the same viscosity characteristics as hitherto. They employ them for the sheathing wires and electric cables, the manufacture of single-thread cords, tapes and other simple thin-walled profiles. Nevertheless it is quite obvious that in spite of these refinements in extrusion technique, difficulties still occur wherever it is a question of spinning profiles which cannot be held in a rigid guide, or by the tension formed as a result of a high take-up speed, as far as the point at which the material becomes rigid—i.e. when making single-thread cords and thin, narrow tapes.

The manufacture of foils, both by means of the blowing and slit die method, the blowing of hollow moulding and the extrusion of tubes and pipes all represent processing problems as no rigid guide can be provided for the fluid mass.

Improved Techniques

As a result of intensive investigations carried out in our laboratories into the process of the polycondensation of ε-caprolactam, we have evolved a technique which makes it possible to produce considerably higher polymers of ε-caprolactam than those on the market at the present time.*


MELTING VISCOSITY IN C POISE
10⁵
10⁴
10³
GRILON TEXTILE
GRILON A25 INJECTION MOULDING
GRILON F35 HIGH MOLECULAR EXTRUSION GRADE
GRILON R 50 HIGH MOLECULAR EXTRUSION GRADE
100 200 300 400 500 600 700 800 900 1000
DEGREE OF POLYMERIZATION

Melting viscosity of various Grilon materials. Constant temperature, 250° C.

Graph 2 shows very clearly the close connection which exists between the degree of the polymerization of ε-caprolactam and the viscosity of the mass. By plotting the viscosity of the mass along the abscissa, which is calibrated on a logarithmic scale, the function can be drawn as a straight line.

The polymer with the lowest degree of polymerization is the one which is processed into fibres and endless yarns. The degree of polymerization of Grilon injection moulding powder, like that of most of the ordinary nylon 6 plastics available, is somewhere between 240 and 300 single molecules. In other words, the high polymer has a chain length of 240–300 single molecules (caprolactam).

A polyamide is now supplied under the name Grilon F35. The degree of polymerization of this product is 560–600 molecules, which means to say that its molecular weight is approximately double that of the usual polyamide plastics found on the market at the moment.

The result of this is that the viscosity at an average working temperature of 250° C. is increased by more than tenfold.

(Grilon A25 = approx. 2'000 cps.)
(Grilon F35 = approx. 30'000 cps.)
(Grilon R50 = approx. 600'000 cps.)

In Grilon R50 the viscosity of the polyamide melt has been considerably raised. Thus the melting viscosity of polyethylene of medium molecular weight is surpassed. This is of particular importance for special problems where the sharp melting point still leads to difficulties of manufacture and therefore a very "viscuous" material over a sufficient temperature interval is necessary.

The high melting point of nylon, however, tends to upset the thermal equilibrium of the machines generally used in the industry today for these very viscous products, and the softening power of the screw type extrusion press drops very sharply.

By regarding the polyamide melt as a Newtonian liquid, the simplified equation based on this concept for determining the plasticizing capacity of a given screw press will show how the liquefying capacity is inversely proportional to the viscosity of the melt produced from the particular plastic material to be processed. However, as the polyamide is both viscous and elastic, it does not permit this mathematical comparison in the strictest sense. This is because considerable shearing stresses occur between the non-liquified granules and the melt in the feed zone, and these shearing stresses are not taken into account in the Newtonian equation. In the F35 melt, with its very high viscosity, these stresses are much greater than with the standard polymer.

There is very clear evidence of local overheating at certain points in the cylinder.

Intensive experiments have therefore been carried out with a view to ascertaining the optimum viscosity for these new grades of Grilon for the manufacture of foils. The materials possess a sufficiently high viscosity to meet most of the problems involved in processing, and the plasticizing capacity of the machine drops a permissible amount. In other words, the frictional heat produced (shearing effect) is kept within proportions which preclude any damage to the material, whilst at the same time it is sufficient to compensate for the decrease in the plasticizing capacity brought about by the increase in the viscosity.

The question of the plasticizing capacity of a machine is not so important for the manufacture of pipes and hoses of larger cross section or for manufacture of bottles by the blowing method, because it has been established, that even the viscosity of Grilon F35 does not always suffice. Grilon R50 closes a gap in such cases and opens new possibilities of application for polyamide plastic.

In addition to the fact that the viscosity of the melt is much higher within the same temperature range, another feature of these high-molecular products is that they have a somewhat flat viscosity curve. Therefore minor fluctuations of a few degrees above the melting point cause much less pronounced changes in the viscosity of the melt. Furthermore, the "plastic interval" near the melting point is somewhat wider.

It is extremely difficult to carry out viscosity tests in the vicinity of the melting point, i.e. below 225° C., as it is not possible to achieve such an accurate temperature constancy at these viscosities. Nevertheless, in this respect a purely practical comparison tells us a great deal more.

If for instance a blown foil is produced from a ring aperture, then in the actual stretching and blowing zone, i.e. where the melt has not yet completely softened and stretching is made possible by molecular orientation, by the air pressure applied at the time, the conditions which prevail are as follows:—

In the case of Grilon standard polymer, the temperature at the ring aperture must be 218 to 222° C., whilst in the case of F35 practically the same "plastic intermediate stage" is obtained at a temperature of 235–245° C.

Consequently, this high molecular Grilon product, being a pure polymer, that is to say a uniform polymer, possesses important features which simplify the task of processing, without any far-reaching changes in regard to chemical behaviour and mechanical properties.

Its behaviour is similar to Grilon grades A25 and A25G in so much as any monomeric components are first of all to a large extent removed. These monomeric components are left in the melt when the polycondensation process is carried out in the autoclave by adjusting the polymerization equilibrium to give 90% polymers and 10% low molecular products, i.e. mainly mono- to tri- polymers. The reasons for this are discussed further in a later section.

* Patents applied for.

International Machine Tool Exhibition London, 1956

THE International Machine Tool Exhibition, 1956, which is being held at Olympia, London, from June 22 to July 6, follows the course set by The Machine Tool Trades Association (of Great Britain) in organizing, every four years, an exhibition in London of all that is new and best in machine tools from all the world's main machine tool manufacturing countries.

The importance of the previous Exhibition, held in 1952, was fully appreciated, coming as it did when manufacturing industry in many countries was going through a period of rehabilitation after the 1939–1945 war. The importance of the coming Exhibition is even greater, for it will not only be the most comprehensive display of machine tools and allied equipment to be held in Europe during 1956, but is also being organized at a time when competition is growing in international trade and when the principles of automation are becoming more widely understood.

The 1956 Exhibition will be the largest of its kind ever held in Britain. 252,000 square feet of stand space at Olympia—the maximum that can be offered—has been booked by exhibitors, who will be demonstrating the performance of their products.

The Properties and Testing of Plastics Materials—Part 4.

Sections 1—7. Colour, Haze, Refraction, Surface Irregularities, Glossiness, Bleeding of Colour, Light

By A. E. LEVER,* A.I.R.I., and J. RHYS,† M.Sc.

Section 1. Colour

TYPES of colourants for plastics are discussed (1) and three fundamental rules for colour performance are given:—

(*a*) Colourants have different properties in different media.

(*b*) The effect of colourants tends to vary with the concentration used, not only in colour results but in other properties.

(*c*) Different processing methods and various applications of plastics stress different colourant properties.

Brief data is presented using Nickerson's Fading Index formula (2) based on easily made Munsell Colour Order readings (3) (4). It is possible to calculate a number that represents the total line value chroma change.

The Hardy type spectrophotometer is used for determining luminous reflectance, transmittance and colour (5). In this type of apparatus, comparison is made automatically and alternately by means of two beams, one of which serves as the standard and the other for the specimen. This method is the fundamental or primary method for obtaining colourmetric data. Its accuracy depends on the adjustment of the instrument and the skill of the operator.

The capabilities and limitations of colour testing is discussed (6).

For colourfastness of p.v.c. sheet, a specification has been issued (7). Details of the exposure frame are given. Standard patterns, according to specification (8) are used for rating.

The resistance of coloured plastics to sunlight (excluding weathering) is measured according to (9). The apparatus consists of a 400 w. bulb with a tungsten filament-mercury arc, enclosed in Corex D glass, and operated at 110 v., with a 15 in. reflector. The samples are exposed on a turntable and colour changes reported by visual inspection, not numerically.

An American specification (10) describes the terms and symbols usually employed in determining the colour of materials.

There is a description (30) of a gauge for determining the fineness of grind of a pigment in a plastic medium. It consists essentially, of a channel of tapered and accurate depth cut in a steel plate. The pigment dispersion is placed at the deepest end of the channel, and drawn along it by means of a standard steel scraper, until the resulting layer of dispersion shows scratch marks which indicates that there are pigment particles in the dispersion which are greater in size than the depth of the channel at that particular point. The channel may have a maximum depth at one end of, say, 0.002 in. and tapered at the other end to the level of the steel block.

There is a full list, with adequate details, of various colour analyzers, colourimeters, etc., in (3). The following instruments are cited, in addition to those mentioned above: Keuffel & Esser Colour Analyzer, Rayek-Milder Colour Analyzer, Pfund Colourimeter, The Blancometer, The Tonometer, The Watson Colour Analyzer, Westinghouse Photo Electric Colour Matcher, Appel-Hickson Spectrometer, The Guild Trichrometric Colourimeter, The Hunter Multipurpose Reflectometer, Bawtree Colourimeter, Lovibond Tintometer, The Eastman Universal Colourmeter, Nickerson Colourimeter.

* Consultant. † F. W. Berk and Co. Ltd.

Section 2. Haze

SURFACES which give a cloudy appearance are described as "hazy," and in order to measure this property the total transmittance of a specimen, and either the rectilinear or diffuse transmittance is required to be determined. The instrument suggested in specification (11) measures the scattered light responsible for the haze.

An American specification (12) uses the Bowen Haze Meter, but this has now been replaced by (11) noted above.

Section 3. Refraction

A SPECIFICATION (13) covers the measurement of the refractive index of transparent organic plastics. An Abbe Refractometer is suggested.

The preparation of the surface is important, and the surface in contact with the fixed half of the refractometer prisms must be quite flat, and a second edge, perpendicular to the first, must also have a good polish.

The containing liquid must have a refractive index at least 0.01 higher than the resin, and not soften it during the test. A list of suitable liquids for various resins is given.

Section 4. Surface Irregularities

A SPECIFICATION (14) covers the determination of the distortion and deviation of a line of sight through flat transparent plastic sheet.

Another specification (15) deals with flat or curved sections of transparent plastics. A telescope is used.

The use of cellulose acetate film for measuring the finish of large engineering components is described (24). The impression obtained is measured directly by a Taysurf Stylus recording instrument.

For measuring the surface roughness of calendered unvulcanized rubber sheet, a nigosimeter has been developed (31).

Section 5. Glossiness

GLOSSINESS is considered to be the visual impression produced by light reflected from a surface (20) or, the ability of a surface to reflect light regularly (3).

None of the instruments available today can rate glossiness, especially in the high gloss range, so as to correlate with visual observations in all cases. There is a comprehensive and interesting discussion, and it is considered that the use of surface traces or coating profiles, is a promising tool in the study of protective coatings.

Another report (21) gives details of an investigation into the gloss of paper surfaces, and the Sheen Gloss (and Mattness) Meter is described (22). It is stated that it covers the whole range from extreme matt to the highest gloss with equal facility.

High gloss specimens can be differentiated best when illuminated and viewed at angles near the perpendicular to the specimen (6). A receiver aperture, not much larger than the source aperture, is of advantage. The "permanent" gloss standards used by the National Bureau of Standards are permanent only if handled with great care.

The Hunter Portable Photoelectric Glossmeter is described (3) and this conforms to most of the conditions required in the Specification for testing the specular gloss of paints (23).

Other glossmeters are the Scofield High Sensitivity Glossmeter (3) and the Pfund Glossmeter (3).

Section 6. Bleeding of Colour

THE diffusion of colouring matter through a coating, from the substrate, also the discolouration resulting from such diffusion (25), is denoted as "bleeding."

This definition is taken from an article describing some of the work which lead up to the development of an A.S.T.M. Standard on the bleeding of traffic paints.

Tests for colour bleeding of p.v.c. sheet are given in (7), and for cables (26). In the latter, samples of the core or sheath cut from the cable, are placed on a sheet of No. 1 Whatman Filter Paper and left at room temperature for three days. After storage, the paper is rubbed on to the cable using light hand pressure, and the paper examined. There shall be no "appreciable staining."

In testing cellulose acetate (27), a 3½ in. diameter circle of good quality, smooth white filter paper shall be dipped in distilled water and allowed to drain for one minute, then laid on a smooth glass plate 4 in. square. The test piece is then laid centrally on the filter paper and another wet one laid on the top of the test piece. The assembly is completed with another glass plate on top. The whole is placed under a 4 lb. weight and allowed to stand for 24 hours at 20–25° C. at 75% R.H. Take out the filter papers and examine for staining against an untreated paper.

A test for compatibility of ingredients in p.v.c., rather than bleeding as such, consists of exposing test pieces to ultra-violet light at 100° F. for 72 hours (28). Bleeding is graded on an arbitrary scale ranging from "no tackiness" to "the formation of drops."

The bleeding of pigments is also covered in specification (29).

" Crocking " is a term used to denote " the migration of a colourant from within the sample to its surface where it can be rubbed off." This can be determined by a modified A.A.T.C. Crockmeter (32).

Section 7. Light

FOR differentiating the relative ability of plastics to diffuse and reflect light, a specification has been issued (16). The Dows-Baumgartner Reflectometer is used, but it is not very sensitive to the measurement of a low range of scattering.

For measuring the light scattering and transmitting properties of planar sections, two instruments are used (11):—

(*a*) The Hazemeter, in which fresh magnesium oxide may be used as the standard.

(*b*) The Recording spectrophotometer.

Another spectrophotometer is described (17) for determining the transparency of materials, especially to infra-red light.

Absorption of radiant energy by plastics, particularly in the near ultra-violet (c3000 Å) affects most translucent types by promoting isomeric or oxidative changes in the molecular structure (18). Discoloration is a result frequently noticed. There may also be an irradiation promoting cross-linking, and the observed result, in this case, is that the resin becomes harder and stiffer.

It is contended (19) that the light fastness of a pigment has no significance and that it is only the light fastness of a pigmentation that can be measured, and have any value. The adoption of the Blue Wool Scale (8) in conjunction with the International Geometric Grey Scale is advocated.

CLARITY AND COLOUR POSSIBILITIES

Typical data	Clarity	Colour possibilities
Phenol formaldehyde Type G	Opaque	Dark colours
,, ,, ,, MS...	,,	,, ,,
,, ,, ,, HS...	,,	,, ,,
,, ,, ,, HR	,,	,, ,,
,, ,, laminates—paper	,,	,, ,,
,, ,, ,, —fabric	,,	,, ,,
Cast phenolics	Transparent to opaque	Unlimited
Urea formaldehyde—paper filled	Translucent and opaque	Pastel shades
,, ,, —wood ,, ...	,, ,, ,,	,, ,,
,, ,, laminates—paper	Opaque	Unlimited
,, ,, ,, —fabric	,,	,,
Melamine formaldehyde...	Translucent and opaque	Pastel shades
,, ,, laminates—paper	Opaque	Unlimited
,, ,, ,, —fabric	,,	,,
Polyesters—unfilled	,,	Limited
Polyester glass laminate—rovings	,,	,,
,, ,, ,, —cloth	,,	,,
,, ,, ,, —mat	,,	,,
Cellulose nitrate	Transparent to opaque	Unlimited
,, acetate	,, ,, ,,	,,
,, acetate—butyrate	,, ,, ,,	,,
Ethyl cellulose	,, ,, ,,	,,
Polyethylene	,, ,, ,,	,,
Polytetrafluorethylene	Opaque	Limited
Polyvinyl chloride (p.v.c.)—rigid	Transparent to opaque	Unlimited
,, ,, (,,)—plasticized	,, ,, ,,	,,
,, ,, —acetate—rigid	,, ,, ,,	,,
,, ,, ,, —plasticized	,, ,, ,,	,,
Polyvinylidene chloride	Translucent	Limited
Polystyrene	Transparent to opaque	Unlimited
High impact polystyrenes and alloys	Opaque	Limited
Polymethylmethacrylate	Transparent to opaque	Unlimited
Nylon moulding powder	Translucent to opaque	Limited
,, filaments	,, ,, ,,	,,
Silicones (elastomeric)	Opaque	Limited
Natural rubber	Translucent to opaque	Unlimited
Hard rubber	Opaque	Limited
Shellac	Transparent to opaque	Unlimited
Casein	Opaque	Limited

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PATENT REVIEW

The following abstracts have been made from specifications at the Patent Office, with the permission of the controller of H.M. Stationery Office. The country of origin for Convention Applications is shown in parentheses. Complete specifications can be obtained from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 3s. 0d. each (including postage).

B.P. 743,743. Flexible hoses. J. Moseley. To: Compoflex Co., Ltd.

An outer tubular member and an inner tubular member with a wire helix in-between. The members may be of a sheet material coated and/or impregnated with polyvinyl chloride.

B.P. 743,749. Jig-saw puzzles. C. W. Phillips.

Three layers of sheet material, two of which are transparent (cellulose acetate). The three layers bear the same pictorial matter but are distinctively coloured so that when superimposed on the white base layer, they produce a multi-coloured picture.

B.P. 743,757. Printing surface. C. L. Sydney. To: P. and J. Arnold, Ltd.

The ink-absorbing part is made of a polymer of vinyl chloride or a copolymer of vinyl chloride and a small amount of vinylidene chloride, vinyl acetate, acrylate characterized by inter-communicating cells not sealed at the working surface.

B.P. 743,766. Stabilized dichromated polyvinyl alcohol coating material. W. W. Triggs. Comm. from: Jones Graphic Products Co.

With increased shelf life for use in making printing plates on a commercial basis.

B.P. 743,775. Apparatus for holding bristles and like brush-making materials. R. Slack. To: E. and G. Slack, Ltd.

A hollow open body with an internally contracting hollow gripping sleeve to maintain the bristles in correct position for grinding, tipping, polishing (tapered nylon).

B.P. 743,846. Production of artificial teeth. F. A. Slack, Jr. To: H. D. Justi and Son Inc.

Multi-shaded artificial teeth are produced by forming distortable parts from a mixture of a polymerizable monomer and a polymerized monomer, then assembling the parts, finally distorting them, shaping them and polymerizing the monomeric constituents.

B.P. 743,900. Laminated materials and method of making the same. MacEchern and Co., Ltd., W. A. George.

Vulcanized fibre sheets and/or fabric base sheets (paper base sheets) the latter impregnated or not with a thermosetting or thermoplastic resin may be bonded with a hot-setting adhesive as, e.g., a phenolic resin by heat and pressure.

B.P. 744,043. Process and apparatus for the manufacture of heat and sound insulating sheet material of bonded glass fibres. To: Algemeene Kunstvezel Maatschappij N.V. (Italy).

A stream of super-heated steam is passed through the web of glass fibres in which a heat hardening agent is uniformly distributed. The excess liquid is expelled, the binding agent dried and hardened.

B.P. 744,050. Nylon mouldings. D. G. Downes. To: Sperry Gyroscope Co., Ltd.

A dimensional stabilizing treatment including the boiling of the moulding in a liquid absorbed by the nylon (e.g., water) and the subsequent desiccating long enough to reduce the quantity of absorbed liquid below the minimum. The mouldings are then immersed in oil till machined, then again subjected to the treatment and re-immersed in oil.

B.P. 744,051. Cellulose derivative or vinyl resin plastic composition. To: Hercules Powder Co. (U.S.A.).

In a composition containing a halogenated aliphatic phosphoric acid ester is incorporated a resinous non-volatile epoxide. Articles made from such compositions are fire-resistant (self-extinguishing).

B.P. 744,060. Cellulose ester compositions. To: Hercules Powder Co. (U.S.A.).

Cellulose acetate compositions are made heat-resistant by incorporating in small proportions an epoxide and a sulphuric acid neutralizing stabilizer.

B.P. 744,093. Method of sizing cellulosic sheet materials. To: Union Carbide and Carbon Corp. (U.S.A.).

Mixtures of starch and a water-soluble, heat-reactive ketone-formaldehyde condensate can be converted into a water-insoluble form in an atmosphere of steam. The treatment increases dimensional stability of paper and fabrics treated with such mixtures and improves their finish.

B.P. 744,099. Separators for electric storage batteries. To: British Fibrak Separator Co., Ltd.

Refers to ribbed separators of, e.g. polyvinyl chloride or paper pulp impregnated with resin.

B.P. 744,108. Regulating means for hydraulic presses for thermoplastic moulding materials. To: Telefonaktiebolaget L. M. Ericson (Sweden).

A hydraulic valve controls the movable platen, another valve the supply of heating and cooling media to the press tools. The closing operation of the platen can begin by manual operation of the first valve. The other valve is automatically operated by an intermittently driven crank eccentric dependent on the movement of the platen.

B.P. 744,130. Models and apparatus for making up models. F. G. Haddock.

A model aircraft (ship, land vehicle) of all-metal or all-plastic construction made up of clips, a skin and two kinds of framework members (tubular and sheet).

B.P. 744,142. Transmission belt of thermoplastic synthetic resin. F. Habegger (Switzerland).

Two strips bonded by fusion. One is a woven synthetic resin fabric strip, the other a preformed synthetic strip of uniform thickness.

B.P. 744,146. Closure devices for containers. J. Reynolds.

Two plugs, e.g., of plastics connected by a flexible band to fit into openings in the container so that the plugs cannot get lost.

B.P. 744,150. Manufacture of waveguide components. J. A. C. Kinnear. To: Elliot Brothers (London), Ltd.

A thin metallic shell is electrodeposited on a mandrel, then encased in a plastic (cold setting resin).

B.P. 744,152. A sound-proof enclosure for electromagnetic vibrators or other apparatus. F. Curzon. To: C. A. V., Ltd.

Two complementary rigid pieces outside (metal or hard plastic), two soft flexible pieces inside.

B.P. 744,177. Production of colour effects in synthetic thermoplastic material. To: Raduner and Co. A.G. (Switzerland).

Heat transferring agents are applied to the material (e.g., nylon) having a boiling point higher than embossing temperature. After embossing affinity for dyestuffs is increased in the embossed areas.

B.P. 744,179. Brushes. To: Osborn Manufacturing Co. (U.S.A.).

Bristle material (wire) is folded about a retaining ring and then enclosed between soft (plastic, metal, rubber) members pressed around the ring.

B.P. 744,217. Dielectric sealing of thermoplastic films. To: Transparent Package Co. (U.S.A.).

Films of vinylidene chloride-vinyl chloride copolymer are sealed by electrodes one of which is heated to 200 to 300° F. and the other kept below the sealing temperature of the film.

B.P. 744,249. Closures for bottles, jars, vials and like containers. J. L. Winfield. To: Glaxo Laboratories, Ltd.

The stopper (self-sealing piercing) is made flush with the neck surface and a flat sealing disc of metallic foils secured to the top surface of the neck of the container by a heat-sealing adhesive (" Telstic ") to form a moisture-proof seal.

B.P. 743,902. Vibrating screens. Siebtechnik G.m.b.H. (Germany).

A fine mesh sieve is fitted in a vibrating sifting machine on a rigid lattice frame with ribs of thermoplastic synthetic material. Heat is applied so that the ribs soften and fill meshes of the sieve to secure it when cooling down.

B.P. 743,904. Casting moulds and compositions for use in the production thereof. To: Monsanto Chemical Co. (U.S.A.).

Shell moulds containing a fusable pulverulent thermosetting condensation product, of which a minor part may be replaced by thermoplastic material.

B.P. 743,908. Pressure sensitive tape dispensing device and process of preparing such tape. G. A. Gerard.

The device incorporates means for manufacturing the tape prior to dispensation to eliminate making coils and providing for storage.

B.P. 743,922. Phosphate plasticizer. To: Celanese Corp. (U.S.A.).

For compositions containing thermoplastic cellulose derivatives. The plasticizers impart fire-retardant properties.

B.P. 743,952. Coating compositions containing synthetic resin. J. Spillmann-Zuppinger.

Coating or plastering material with Portland cement as main constituent. Methyl-cellulose and finely divided polyvinyl ester (polyvinyl acetate) are incorporated with Portland cement and lime to obtain a mixture which can be applied as a coating.

B.P. 743,979. Crepe rubber. D. G. H. Baxter, J. H. Robinson. To: Britiona Chemicals, Ltd.

Adhesion of crepe rubber soles and heels is increased by incorporating short lengths of (nylon, cellulose ester, etc.) fibre throughout in a homogeneous manner.

B.P. 744,005. Coated regenerated cellulose film. To: Transparent Package Co. (U.S.A.).

An ester reaction product is applied as a liquid mixture with other components to the film. The moisture-proof seamless tube is used in making liver sausage to be heat treated during processing.

B.P. 744,277. Acid-tight joint for electrical storage batteries and method of producing the same. Oldham & Son, Ltd., H. Lennie.

Refers to the fixing of a lead terminal post in a plastic lid. The aperture for the post is closed by pouring a thermo-setting plastic substance into a recess surrounding the aperture. After setting an acid-tight joint forms between lid and post.

B.P. 744,280. Process for the preparation of polymers. To: Chemische Fabrik Schönenwerd H. Erzinger A.G. (Switzerland; Germany).

A polymerization process for monomeric methacrylic acid methyl ester together with its polymers used, e.g., in dentistry (fillings, artificial teeth, repairs..

B.P. 744,327. Process and apparatus for the manufacture of catheters and the like. W. Ruesch (Germany).

A uniform tube (of, e.g., polyvinyl chloride) is extruded and cut to form a tube with a closed end. The deformation of individual parts is effected by heating with high frequency currents followed by immediate cooling.

B.P. 744,343. Apparatus for treating webs of thermoplastic material. To: Svenska Vaxduks A.B. (Sweden).

The webs of polyvinyl chloride or polyethylene to be printed are guided over a drum heated outside along a part of the periphery and cooled inside. The web is kept in contact with the drum for cooling after it has passed the heating zone. The heating is required for the material to take the printing ink.

B.P. 744,369. Vaporizing attachments for bottles or like containers. H. W. B. Baker. To: Goya Ltd.

A cap with an internal threaded boss into which a wick support is to be screwed from underneath.

B.P. 744,377. Process for flame spraying plastisol. To: Union Carbide & Carbon Corp. (U.S.A.).

The plastisol containing a vinyl resin and a liquid plasticizer is atomized into a spray of particles, passed through a flame to form a partially gelled dispersion to which additional heat is supplied. The deposited particles then fuse into a continuous coating.

B.P. 744,452. Display boxes. To: Stanley Rogers & Son, Ltd. Comm. from: S. Rogers.

A tray for cutlery or silver is slid into a transparent container with curved top (lid and body part). This transparent container is then inserted in an outer (opaque) box. After removal of the box cover the tray is displayed but still protected.

B.P. 744,455. Shock-resistant plastic compositions. To: Union Carbide & Carbon Corp. (U.S.A.).

Copolymer resin of butadiene, styrene and acrylonitride, containing from 23 to 41% butadiene, 10 to 30% acrylonitride, 29 to 67% styrene.

B.P. 744,472. Thermo-setting composition. F. Armitage, L. G. Trace. To: Lewis Berger & Sons, Ltd.

An admixture of a cinnamic acid ester or partial ester of an epoxy resin and a styrene for insulation of high-frequency coils to be used in tropical conditions.

B.P. 744,488. Carrier for fly or like fishing casts. R. S. Hill.

A moulded disc with apertures and a rotatable indicator to prevent detachment of the flies in the wrong sequence.

B.P. 744,494. Terminations for high frequency waveguides and coaxial lines. E. A. N. Whitehead, J. A. C. Kinnear. To: Elliott Brothers (London), Ltd.

At least part of one of the normally electrically conducting boundary surfaces is formed from a " dielectric material " (a suspension of fine carbonyl-iron dust in Marco Resin).

B.P. 744,500. Electrical insulating materials. To: General Electric Co. (U.S.A.).

An impregnant for fibrous material containing 19–46% phenol formaldehyde, 3–27% polyvinyl chloride, 2–11% aniline formaldehyde in the final product which is then dried and cured under heat and pressure.

B.P. 744,506. Spectacle frames. F. O. Wheway.

With removable decorative pieces for each brow bar.

B.P. 744,519. Thermo-setting composition. F. Armitage, L. G. Trace. To: Lewis Berger & Sons, Ltd.

(Divided out of 744,472.)

B.P. 744,521. Tie bands. R. D. Boyce.

Each end of a length of tape is provided with a tacky adhesive protected by a detachable strip of non-adhesive material.

B.P. 744,591. Ultrasonic vibratory devices. To: Raytheon Mfg. Co. (U.S.A.).

E.g., for bonding plastics.

B.P. 744,653. Vibratory tools. To: Raytheon Mfg. Co. (U.S.A.).

(Divided out of 744,591.)

B.P. 744,669. Production of moistureproof sheet wrapping materials. R. A. Rose, W. G. Harland, J. A. V. White. To: British Cellophane, Ltd.

Spreading of the dispersion past the edges of the film is restrained by wedges made of, or faced with, polytetrafluoroethylene. (Add. to 663,645.)

B.P. 744,671. Spectacle frames. S. S. Scriven. To: Scrivens (Manufacturing Opticians), Ltd.

(Divided out of 733,818.)

B.P. 744,677. Production of moistureproof films. W. Barry, R. A. Rose. To: British Cellophane, Ltd. (Add. to 677,926.)

B.P. 744,738. Printing of coloured pictures or the like. J. G. Lindmark (Sweden).

On a transparent base (" Diophane "). The base is matted and the picture components printed laterally reversed and in the reverse order to that employed when printing on paper. When viewed through the base material, the picture will be sharper, brighter and of an extraordinary impression of depth.

B.P. 744,748. Plastics containers filled with fluid material. V. Flax.

The plastics tube, after filling, is welded along transverse lines and also along longitudinal lines to subdivide it into containers joined together side by side.

B.P. 744,750. Production of plastics containers filled with fluid material. V. Flax.

Relates to the filling and subdivision of lengths.

B.P. 744,800. Attachment for coat hangers to enable additional garments to be suspended therefrom. M. M. Collings.

A bar with hooks is provided with a ring and screw to attach it to the yoke of a hanger.

B.P. 744,823. Eyes for dolls, toy animals and the like. D. G. Todd, J. Robinson.

A plastic strip simulates eyelashes. It is moulded integrally with one convenient part of the eye.

B.P. 744,835. Electric lighting fittings. E. H. Maddox. To: Ionlite, Ltd.

Composed of a pair of dished elements (minor segments of a sphere). The lower element is moulded of transparent or translucent plastics, the upper element may be of plastics or metal.

B.P. 744,850. Devices or appliances for use in education and recreation of children. C. A. Tacey. To: Philip & Tacey, Ltd.

Blocks of plastic with rectangular spigots and holes to be assembled in line.

B.P. 744,875. Polythene. J. D. Burnett, N. D. Huck. To: Imperial Chemical Industries, Ltd.

Refers to phenols of high molecular weight as antioxidants for polythene.

B.P. 744,895. Extrusion-moulding of plastics. To: Injection Molding Co. (U.S.A.).

Plastics material is supplied from extrusion machines in sequence to die heads with mandrels to form hollow containers. The supply is controlled by valves in the ducts opening one duct while closing another duct.

B.P. 744,902. Car licence holders and the like. S. A. Bates.

Two sheets secured around the periphery leaving an aperture for the licence. One sheet of polished transparent plastic which adheres to polished glass when pressed thereon.

B.P. 744,904. An appliance for slicing tomatoes and other fruits, vegetables or the like. E. Meeson.

A cutting blade across a partly open box-like one-piece moulding.

B.P. 744,909. Carbon paper or the like. F. G. Francis.

On a very thin supporting film of tough and resilient polythene.

B.P. 744,927. Manufacture of hollow articles from organic plastic materials. To: Lacrinoid Products, Ltd.

To expand an extruded hollow body (bottle) of polyethylene, cellulose esters, polyvinyl chloride, polystyrene, a reciprocating movement is imparted to the extrusion nozzle or mould so that the body is expanded while mould and nozzle move away from each other.

B.P. 744,976. Equipment and method for making elongated shapes from synthetic linear Polyamides. To: Polymer Corp. (U.S.A.).

Continuous production of uniform (solid or tubular) rods from a stream of molten polyamide fed into a forming tube is obtained by regulating the advance of the formed rod, e.g., through a pair of rolls engaging the rod beyond the delivery end of the forming tube.

B.P. 744,977. Production of films of thermoplastic materials. B. Samways. To: British Cellophane, Ltd.

A seamless tube is extruded, cooled and processed, then flattened. The flattened tube is wound as a roll. The edges may be creased and cut before winding. The flattening and winding means rotate about an axis perpendicular to and coinciding with the centre line of the extrusion die.

B.P. 744,986. A toilet powder container incorporating a permeable pad. D. H. Blake.

B.P. 744,996. Thermosetting composition. To: Lewis Berger & Sons, Ltd.

Materials for the insulation of high frequency coils to be used under tropical conditions (sorbic acid ester copolymerized with styrene).

B.P. 745,005. Devices for indicating hands in card games. M. Daniels.

B.P. 745,017. Liquid dispenser. T. Whittle.

B.P. 745,021. Manufacture of doors or panels primarily for furniture. Supersuites, Ltd., J. Angel.

A laminated built-up door or panel including a distinctive undulation and a sharp bend or step is formed from assembled long-grain and cross-grain wood veneers on a mould element under heat and pressure using a synthetic resin bond.

B.P. 745,024. Metal food and beverage containers. J. A. Shollon. To: Phillips Petroleum Co.

Coated internally with hydroxylated conjugated diolefin polymers and/or esters thereof to make them resistant to food acids.

B.P. 745,060. Polyvinyl chloride compositions. H. Reichard. To: Vinyl Products, Ltd.

Improved bonding properties to surfaces of metal, fabric, glass, ceramics. A thermo-set epoxy resin and a hardener are incorporated in a polyvinyl chloride paste.

B.P. 745,103. Manufacture by moulding of pulleys, rollers and the like. G. F. Sly. To: United Ebonite & Lorival, Ltd.

A die construction for moulding such parts incorporating a ball bearing, in which during moulding the bearing is held in the two-part die between upper and lower parts of a central pin. The lower part is fixed in the bottom die and the upper part screws into the lower part.

B.P. 745,111. Toy bells as used for decoration and amusement. R. Gratzer.

The bell-shaped body is closed at its lower end its upper end being fitted with a cap secured by a spreading spring wire loop. The clapper hanging from the cap produces a loud tinkling.

B.P. 745,118/9. Rigid shock-resistant vinyl halide polymer compositions. To: B. F. Goodrich Co. (U.S.A.).

B.P. 745,149. Thermoplastic compositions. W. Saul. To: Semtex, Ltd.

Seventy-six to 50% of the total weight is a filler (fibrous, non-fibrous, asbestos, powdered limestone) dispersed in a binder containing a polyvinyl resin, a plasticizer and a blown vegetable oil.

B.P. 745,204. Manufacture of micro-porous screens. To: Cie. de Caoutchouc Manufacture " Dynamic " (France).

A micro-porous diaphragm (separators for electric accumulators, etc.) is made from a mixture of polyvinyl chloride, powdered silica gel, tricresyl phosphate, moulded, precompressed and heated.

B.P. 745,214. Expanded thermoplastic material. W. H. Hogg, G. B. Daroy. To: Dunlop Rubber Co., Ltd.

Plastisols of thermoplastic resins can advantageously be used in the production of expanded resinous material by frothing in the presence of a thickening agent.

B.P. 745,264. Writing pads. H. R. Pearce. To: Leswick Ltd.

The type of pad in which a semi-transparent sheet is mounted in a casing over a sheet covered with an adhesive layer (dark coloured paraffin wax) both under a protective transparent cover, is provided with a continuous writing surface by forming each of the sheets as a continuous band moving around rollers in a frame.

B.P. 745,288. Manufacture of shell moulds. A. B. Smith, E. R. Smith.

The heating (curing and hardening) step is effected by a rapid and closed circuit treatment in which air at relatively low temperature is circulated continuously by a fan on to the exposed back of the shell.

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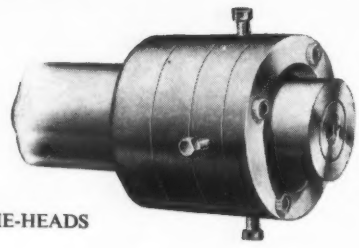
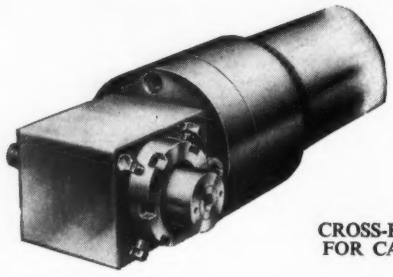
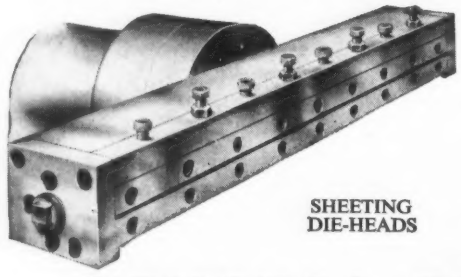


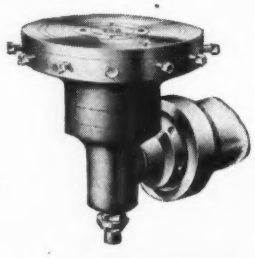
TUBING DIE-HEADS



CROSS-HEADS FOR CABLES



SHEETING DIE-HEADS



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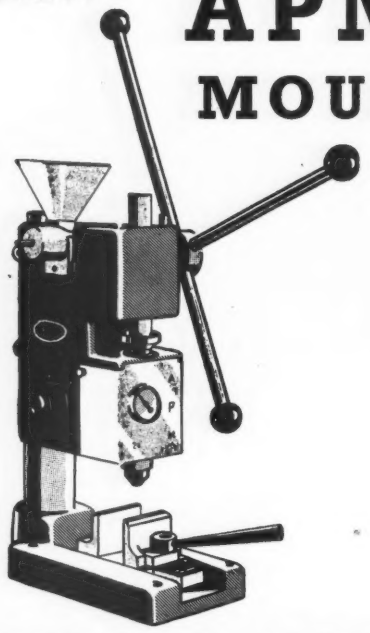

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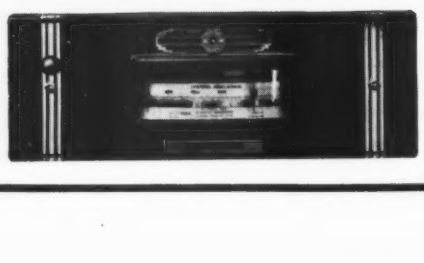

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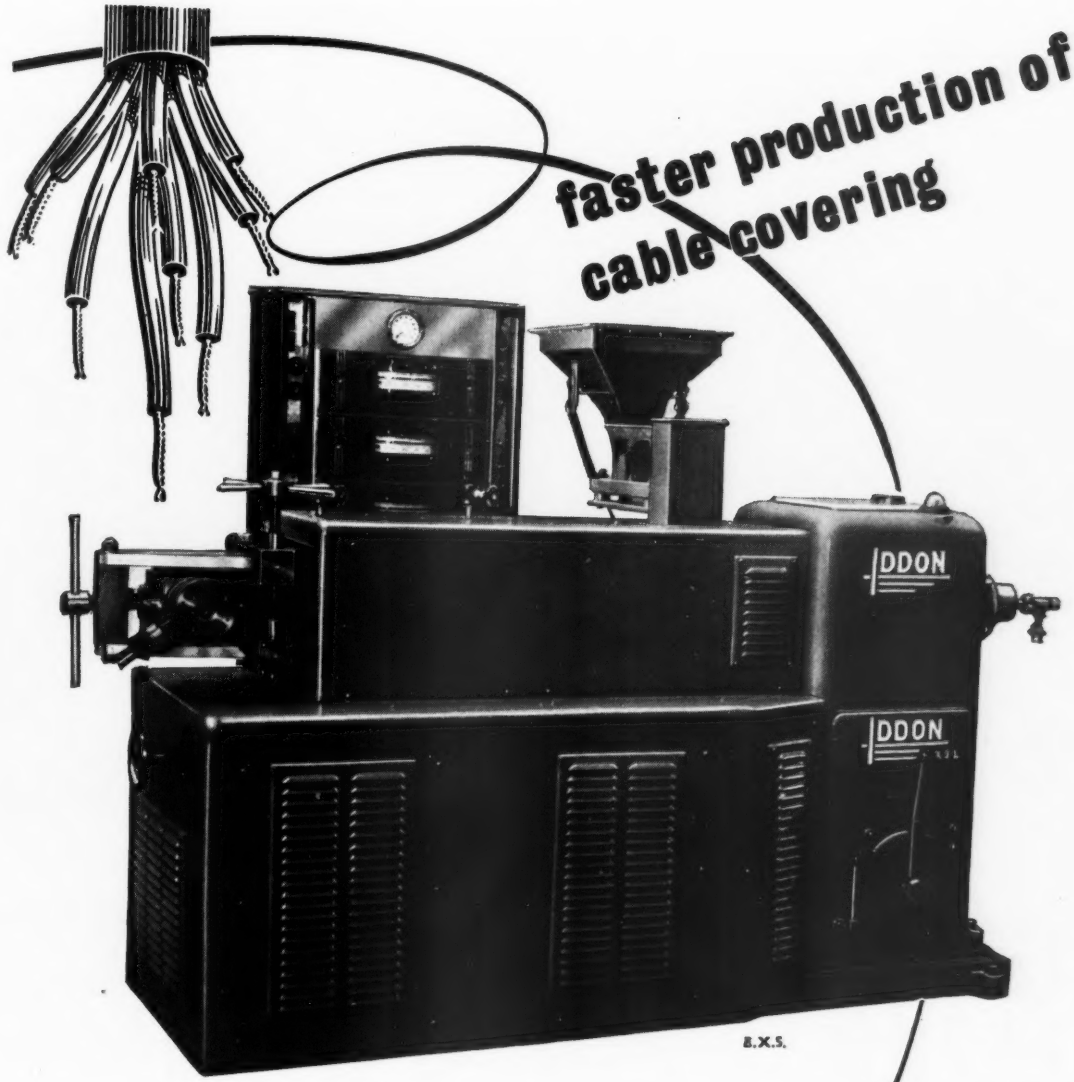

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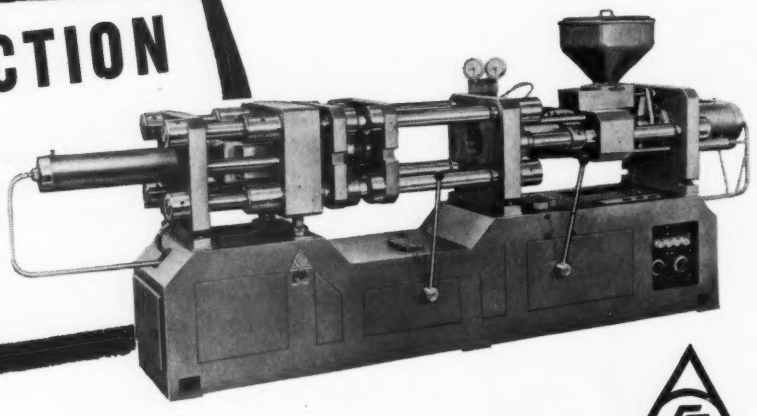

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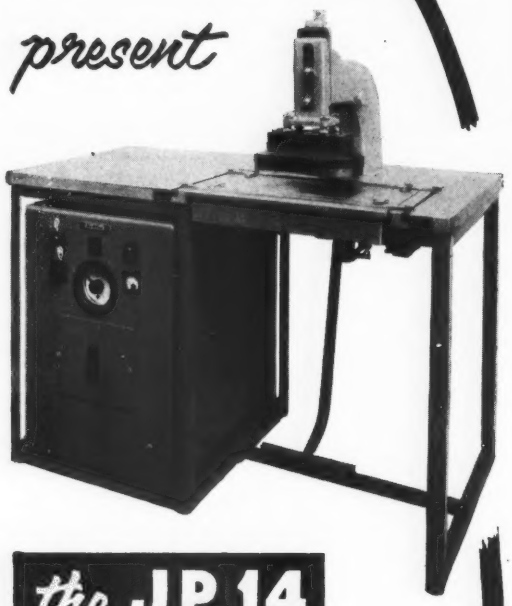

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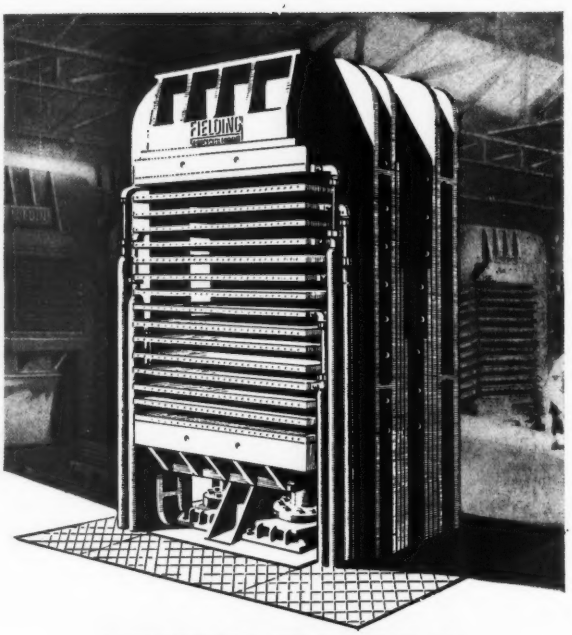

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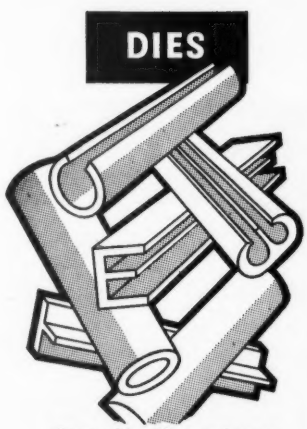

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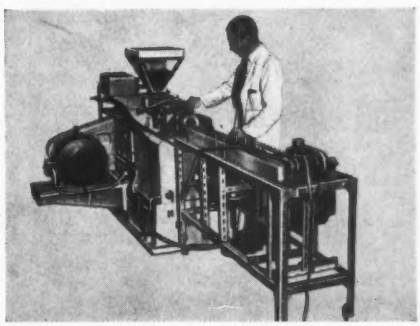

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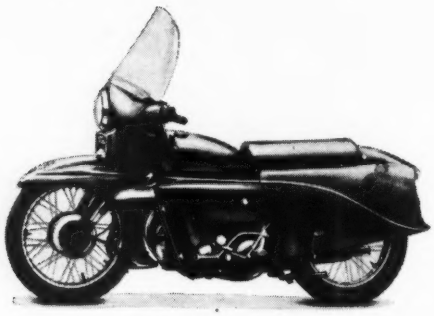

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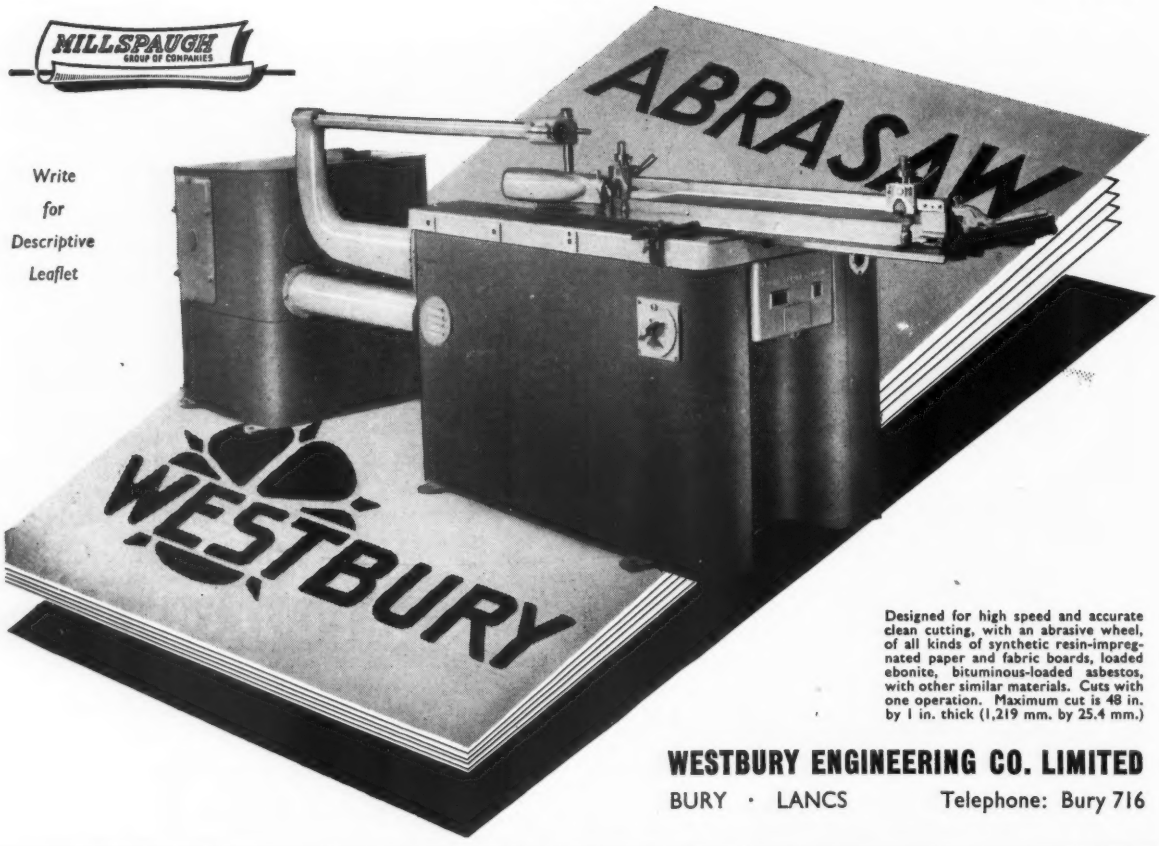

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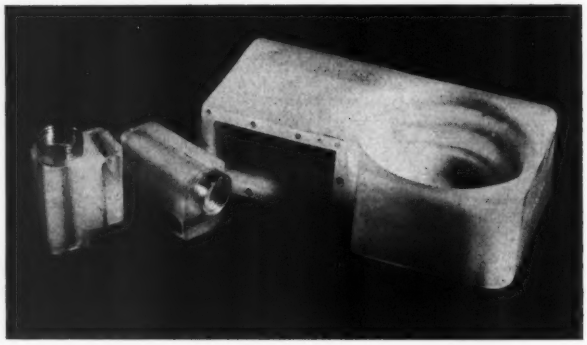

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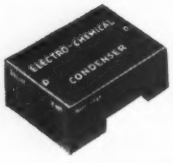

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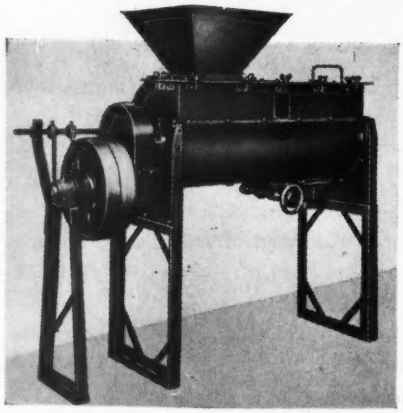

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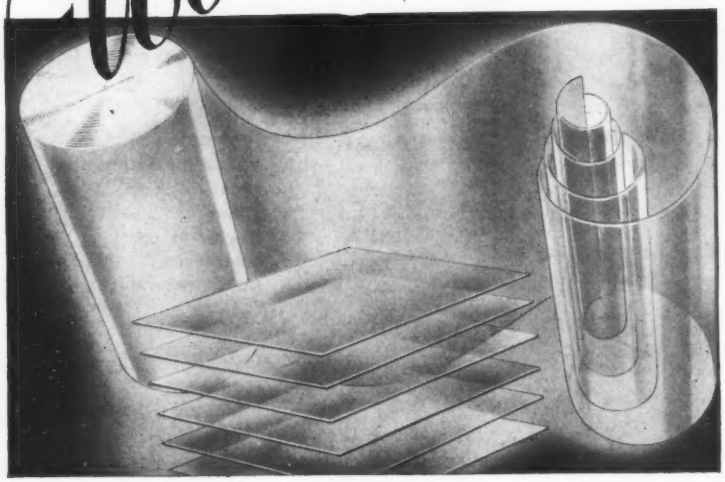

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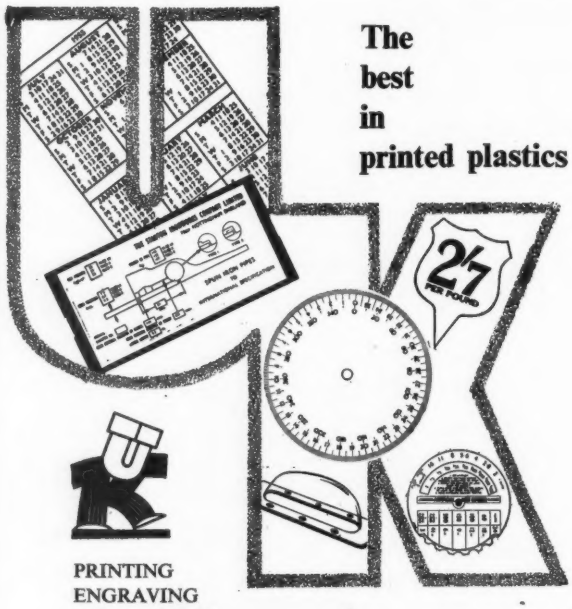

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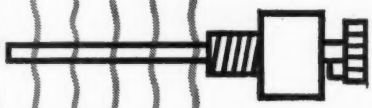

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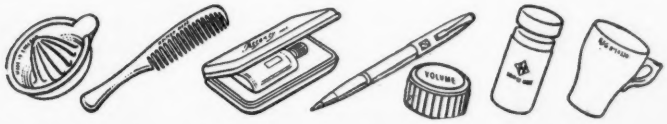

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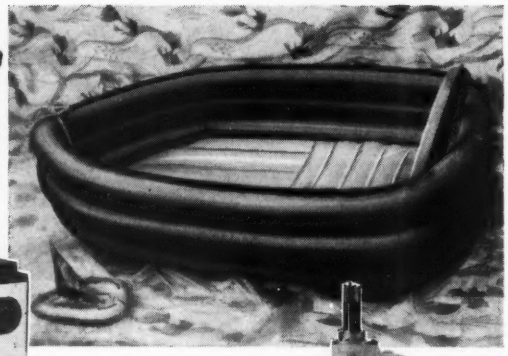

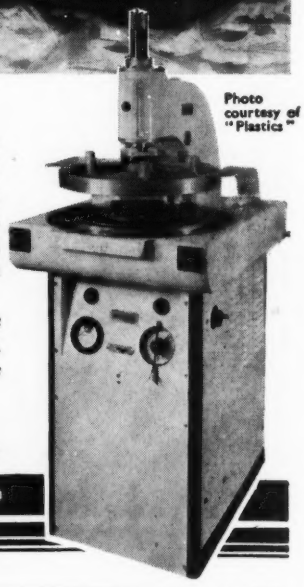

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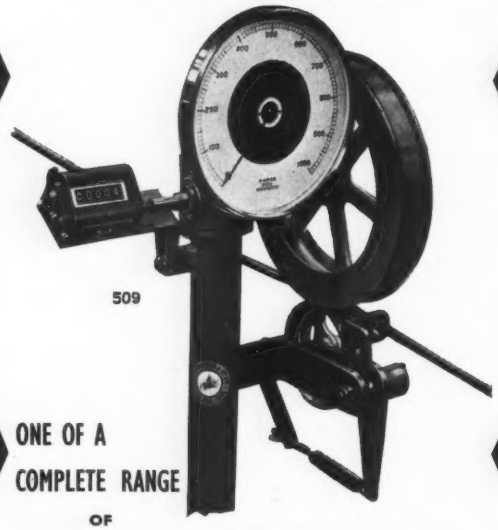

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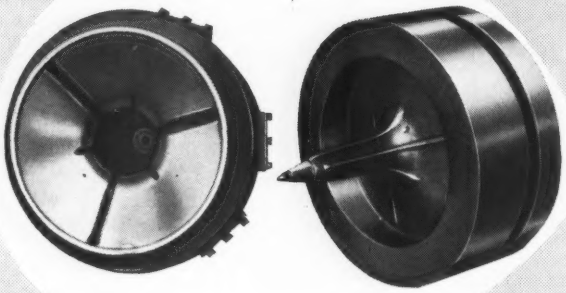

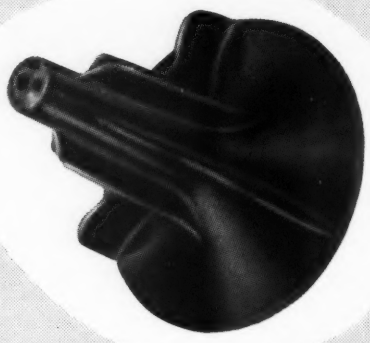

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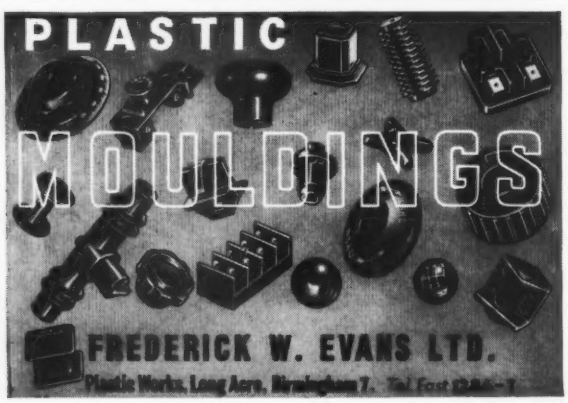

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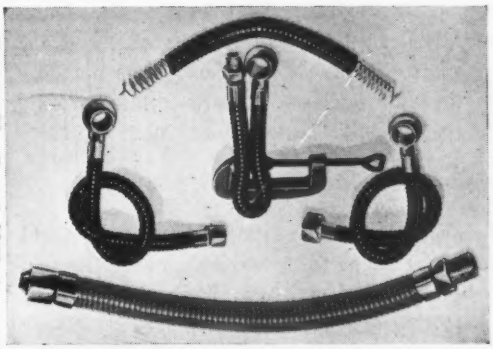

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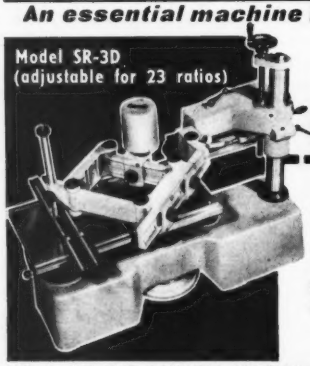

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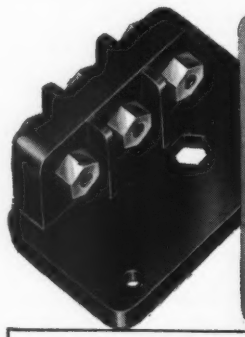

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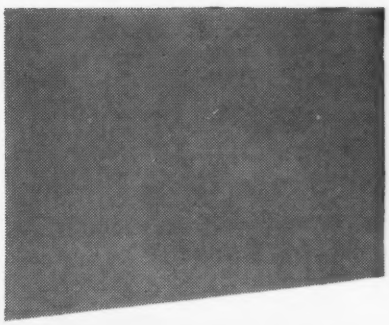

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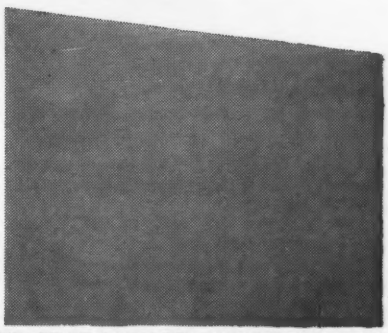

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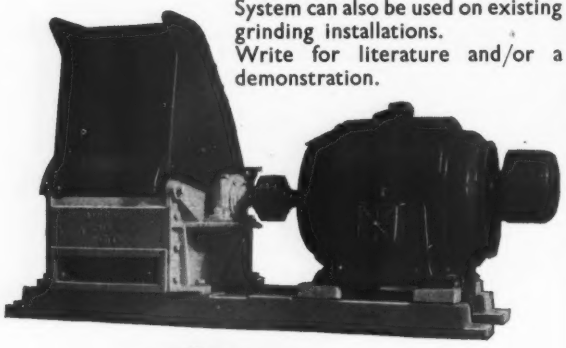

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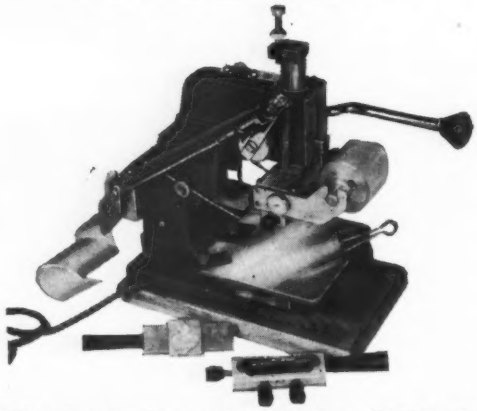

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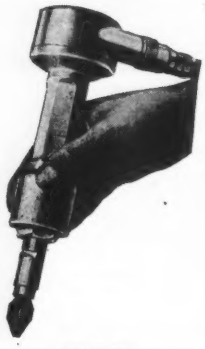

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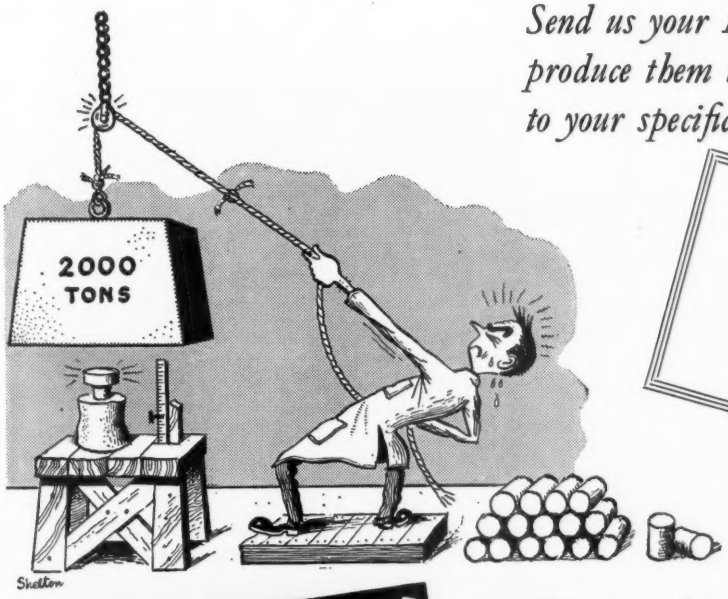

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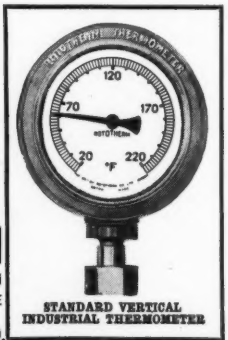

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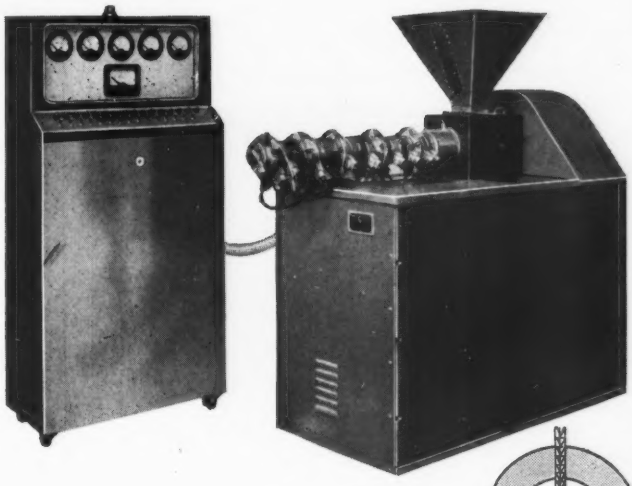

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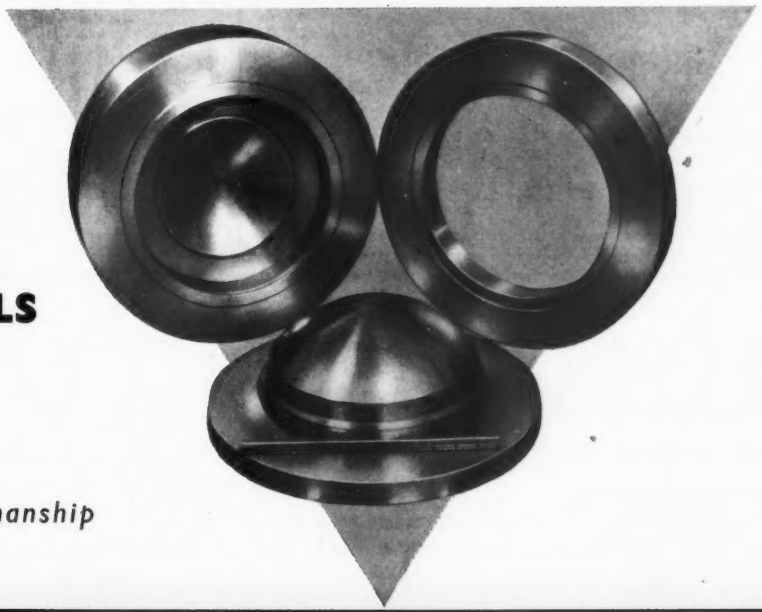
High-Class Workmanship At Low Cost



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TREND CUTTING TOOLS CUT COSTS!

Let us demonstrate on your premises, the POWER AND VERSATILITY of our **LESTO ELECTRIC SAW** (product of Scintilla, Soleure, Switzerland).

Irregular shapes cut in:—

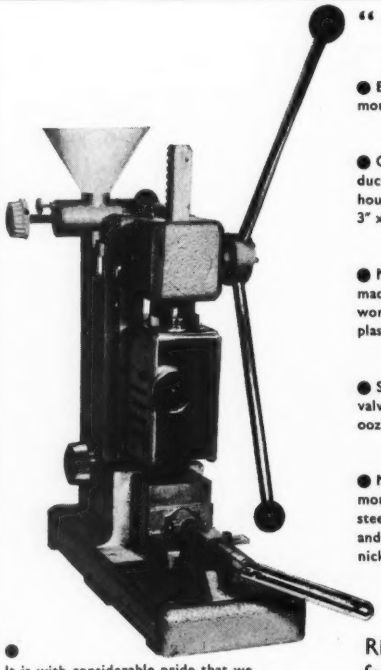
★ FIBREGLASS/POLYESTERS
★ WARERITE OR FORMICA
★ TUFNOL AND SINDANYO
★ PERSPEX
★ ALUMINIUM AND STEEL SHEET

Above illustration shows: Fibreglass/Polyester Car Hood being trimmed by our LESTO SAW, Type GEB 11, with special attachment fitted for negotiating uneven surfaces. Immediate delivery. Prompt Service. Weight of Tool only 5¾lbs.

Price (excluding attachment) **£28.10.0.**

TREND INDUSTRIAL EQUIPMENT LTD.
5, RIDGEWAY, STANMORE, MIDDX. Tel. Grimsdyke 727.

"PEPCO"



- Bench-type injection moulding machine.
- Capacity ⅜ oz. Production rate 120 per hour. Mould dimensions: 3" x 3" x 2".
- Most versatile machine suitable for working all thermoplastics including *nylon*.
- Special "non-drip" valve fitted, preventing oozing from the nozzle.
- Most comprehensive mould service in stainless steel, nickel chrome steel and electro-formed hard nickel tools.

It is with considerable pride that we present our new model—an efficient bench-type machine which provides the answer to many day-to-day problems in industry.
The simplicity of operation, coupled with the low cost of moulds, makes this the most versatile machine of its kind on the market.

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REPROCESSED POLYSTYRENE

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Designers and Toolmakers
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Cellulose Acetate . Polythene . Polystyrene
Aceto-Butyrate . P.V.C. and Co-polymer
Polystyrene/rubber compound

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(LONDON SALES OFFICE FOR THE GROUP)
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Virgin high acetyl and standard, cellulose acetate moulding powders. We are able to reprocess your redundant stocks and scrap into first class moulding powders. We would be pleased to make you an offer for your scrap. Prompt deliveries of virgin and reconstituted powders.

LET US SOLVE YOUR MATERIAL PROBLEMS—THERMOPLASTICS IS OUR BUSINESS

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.... trouble is, he's so keen on G.G.L that he keeps talking about their wonderful service even when you want to concentrate on something else. I quite agree that there's nobody like G.G.L. for Capstan Work, Pressings and Automatic Productions....
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requires TECHNICAL ASSISTANTS for development and experimental work. Applicants should preferably be educated to H.N.C. standard or equivalent in Chemistry and have some knowledge and experience of Thermoplastics, P.V.C., Polythene and Nylon. They should have good practical conception and be able to assess and report objectively. As the work is mainly in the factory, an interest and understanding of machinery is required, also a personality which ensures co-operation from production supervisors and operatives. Five-day week, Pension Scheme and all welfare facilities. Write details to:

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Specialists in

AUTOMATIC TURNED PARTS
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METAL INSERTS FOR MOULDINGS

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P.V.C.

Classified Advertisements

PRESS DAY.—Classified advertisements for the July issue must be received at Head Office by first post Monday, June 25.

Last-minute additions and deletions are accepted by telephone from trade advertisers up to noon. Advertisements received too late for a particular issue are automatically inserted in the succeeding one unless instructions to the contrary are received.

RATES.—4d. per word (minimum 12 words 4/-). Each paragraph charged separately and name and address must be paid for. Semi-displayed setting 35/- per single column inch. Series discounts of 5% for 6, and 10% for 12 consecutive insertions allowed to trade advertisers.

TERMS.—Strictly net and prepayable. Monthly accounts for settlement by the end of the month following insertion are allowed to trade advertisers if satisfactory references are provided.

REMITTANCES.—Cheques and postal orders should be crossed and made payable to TEMPLE PRESS LIMITED and instructions sent addressed to the Manager, "Plastics," Bowling Green Lane, London, E.C.1.

THE PROPRIETORS retain the right to refuse or withdraw advertisements at their discretion and are not responsible for clerical or printers' errors although every care is taken to avoid mistakes.

BOX NUMBERS.—Private advertisers desiring to have replies sent care of "Plastics" may do so on payment of 1/- to cover booking and postage, plus cost of four extra words. To avoid mistakes in forwarding, Box numbers should be carefully and legibly copied and replies sent to Box P000, care of "Plastics," Bowling Green Lane, London, E.C.1.

DEPOSIT SYSTEM.—Facilities are available to readers to purchase advertised goods on approval by depositing the purchase price with "Plastics." Full details on application. Commission 1% (minimum 2/-) on amount deposited.

HEAD OFFICES.—Bowling Green Lane, London, E.C.1, England. Telephone: Terminus 3636. Telegrams: "Pressimus, Phone, London."

BRANCH OFFICES: 7, John Bright Street, Birmingham, 1. Telephone: Midland 4117-8. 50, Hertford Street, Coventry. Telephone: Coventry 62464. 1, Brazennose Street, Manchester. Telephone: Deansgate 6114-8. 12, Renfield Street, Glasgow. Telephone: Glasgow Central 1413.

AGENTS WANTED

AGENT already established in the plastic industry required to represent expanding Injection Moulding Manufacturers in the North of England. Reply in confidence to Box P.252, care of "Plastics." 225-16

AUCTIONS

ESTABLISHED 1855.
EDWARD RUSHTON, SON AND KENYON,
INDUSTRIAL VALUERS, AUCTIONEERS AND
FIRE LOSS ASSESSORS.
12 YORK STREET,
MANCHESTER, 2.
Phone, Central 1937–8.
Grams, Russonken, Manchester. zzz-304

BUSINESSES, PREMISES, OFFICES, ETC.

FACTORY ACCOMMODATION
FOR SALE OR LEASE
available in
BOURNEMOUTH – POOLE.
Managing Agents:
REBBECK BROS.,
THE SQUARE, BOURNEMOUTH. 225-5

BUSINESS OPPORTUNITIES

WANTED PRESSING CAPACITY, presses must be multi-platen bored for heating and water cooling, size of platens preferably larger than 18 × 21 in. Please write stating pressure available, etc., to Downes, 75 Hampton Hill, Hampton, Middlesex. 225-15

WANTED TO PURCHASE.

THE MARLEY TILE COMPANY, LIMITED,

IS INTERESTED IN PURCHASING

A BUSINESS WITH GOOD MANUFACTURING

FACILITIES OF PLASTICS PRODUCTS.

MUST HAVE POSSIBILITIES FOR EXPANSION.

COMMUNICATE IN CONFIDENCE TO:—

THE MANAGING DIRECTOR,

THE MARLEY TILE COMPANY, LIMITED,

RIVERHEAD,

SEVENOAKS, KENT.

229-1214

CONSULTANTS

CREATIVE PRODUCT DESIGN IN PLASTICS. W. Bruce Brown, M.S.I.A., F.R.S.A., 140 Roding Rd., Loughton, Essex. Loughton 4138. 226-1212

DESIGN AND DRAWING

FOR MARKING AND PRINTING, dials, scales, rulers, etc., on any plastic fabricating, milling, stamping, etc. Convex, Ltd., 41 Brecknock Rd., N.7. 225-31

MACHINERY, TOOLS AND PLANT

FOR SALE. Universal vacuum mixing machine. Size 14, Baker Perkins. Having Sigma blades, steam-jacketed. Fitted with liners, wet vacuum pump, 12 h.p. motor and reduction gear. Almost brand-new. Box P2410, care of "Plastics." 225-1200

HYDRAULIC. Frazer mono-radial pumps, new and second-hand in stock. Thompson and Son (Millwall), Ltd., Cuba St., London, E.14. East 1844. zzz-302

HYDRAULIC PRESSES

625-ton upstroke Press by England. Ram 18 in. dia. × 5 ft. stroke. Four Steel columns 7 in. dia. distances between 73 in. × 21 in. Moving table, working area 6 ft. × 4 ft. Daylight 6 ft. can be reduced.

500-ton Downstroke Press by Greenwood & Batley, 18 in. dia. Ram × 28 in. stroke. Four Columns 6 in. dia. 22 in. × 17¾ in. between. Fully guided table, working area 31 in. × 22 in. Daylight 42 in. WP. 2 t. sq. in.

400-ton UPSTROKE PRESS by Greenwood & Batley, Ram 16 in. dia. × 28 in. stroke. WP. 2 tons sq. in. Four columns 5 in. dia., distance between 22 in. × 17½ in. With nine steam-heated platens 36 in. × 17 in. giving eight daylights 2⅞ in.

Five 400-ton Greenwood & Batley PRESSES, Ram 16 in. dia. × 24 in. stroke. Table 30 in. × 17½ in. admitting 20½ in. and 17½ in. between columns. Four Steel screwed columns 5 in. dia. Daylight table to head 4 ft. WP. 2 tons sq. in.

375-tons Multi Daylight PRESS by John Shaw. Ram 15½ in. dia. × 5 ft. stroke. Four columns 5½ in. dia., distances between 72 in. × 20 in. Fitted 10 steam-heated Platens 72 in. × 50 in. giving nine daylights of approx. 3 in. WP. 2 t. sq. in.

300-ton Downstroke PRESS by M. B. Wild, 20 in. dia. Ram × 48 in stroke. Four columns 6 in. dia., distances between 36 in. × 23 in. Fully guided table working space 36 in. × 28 in. Daylight 5 ft. WP. 1 t. sq. in.

Two 120-ton Downstroke Moulding Presses by Hydraulic Eng. D.A. piston type Ram 8½ in. dia. × 14 in. stroke. Fixed and moving tables fitted detachable tee slotted bolster working area 24 in. × 21 in. WP. 2 t. sq. in.

80-ton DOWNSTROKE PRESS by Finney. Ram 10½ in. × 18 in. stroke. Four Columns 3 in. dia., distance between 21 in. × 10 in. WP. 1 ton sq. in. Fixed and fully guided moving tables, working area 18 in. sq.

70-ton UPSTROKE PRESS by Oram. Ram 9 in. dia. × 42 in. stroke. Four Columns 3¾ in. dia., distance between 5 ft. 10¼ in. × 18 in. Semi-guided moving table 5 ft. 10½ in. × 44 in. Daylight approx. 6 ft. WP. 2,500 lb. sq. in.

GEORGE COHEN, SONS & CO., LTD.,
WOOD LANE, LONDON, W.12.
Phone, Shepherds Bush 2070.
AND
STANNINGLEY, NR. LEEDS.
Phone, Pudsey 2241. 225-21

Machinery, Tools and Plant (contd.)

MIXERS AND BLENDERS. Usually a varied selection available for quick delivery. Inquiries welcome. Winkworth Machinery, Ltd., 65 High St., Staines. 226-1213

THREE BOWL EMBOSSING CALENDER with pigskin and polished embossing rollers 72 in. wide, complete with infra red preheating equipment for P.V.C. sheet and coated cloth, variable speed drive and motor. For sale. Box P.255, care of "Plastics." 227-1216

150/250-TON PRESS capacity available. Apply Box P2511, care of "Plastics." 225-24

£18/20 SAVED!!! on each "BELLBRO" dust, fume Extracting-Blowing Motorised Fan unit. Numerous satisfied users. Literature from:—Bellangers, 306 Holloway Rd., London, N.7. North 4117. 225-18

PLASTICS MACHINERY.
Hydraulic Presses of all sizes. Injection Machines. Extruders. Mixing Mills. Hydraulic Pumps and Accumulators.
Send your requirements to the specialists.
REED BROTHERS (ENGINEERING), LTD.,
REPLANT WORKS,
CUBA STREET, MILLWALL, E.14.
Phone, East 4081 (five lines). 225-52

SORENSEN'S
OFFER
50 HUNTS, HOBARTS, ETC.
GOVERNMENT SURPLUS
DOUGH AND CAKE MIXERS
AT
HALF MAKERS' PRICES.
Reconditioned and Guaranteed.
RABY STREET WORKS,
MANCHESTER, 16.
Phone, Moss Side 2054. Grams, Rahbek.
227-1221

MACHINERY FOR SALE

FOR SALE. Four Bradley & Turton 100-tons hydraulic downstroke moulding presses without pump in working condition. Offers invited to De Garrs & Allen Ltd., Harwood St., Sheffield, 2. Phone, 20909. 225-41

MACHINERY, TOOLS AND PLANT WANTED

MIXERS AND BLENDERS of all types and sizes. Any locality. Winkworth, 65 High St., Staines. 226-x3786

URGENTLY WANTED, secondhand Vertical Type Injection Moulding Machine, preferably Battenfeld capacity 35 gram, required by Newfeld Ltd., Newfoam Works, Spelthorne Lane, Ashford, Middlesex. 225-23

WANTED—2 oz. Hupfield Machine. Please state condition, serial number and price. Box P2510, care of "Plastics." 225-25

WANTED. Machinery new or secondhand for the production of casein rods and blanks. Box P2519, care of "Plastics." 225-62

MATERIALS WANTED

THERMOPLASTIC MATERIAL
(any quantity urgently required)
MULTITEX LIMITED,
7-8 BULMER MEWS,
NOTTING HILL GATE,
LONDON, W.11.
Phone, Park 2611. 225-46

MISCELLANEOUS

EXTEND YOUR TRADE. Use a trade mark. Consult Trade Mark Protection Society, 12 Church St., Liverpool. zzz-294

MOULDS

COMPRESSION MOULDS available for export, for production of:—Ashtrays, Cigarette Boxes, Household Articles, Fancy Goods, etc. Write for full details Box P254, care of "Plastics." 230-1215

PATENTS

THE PROPRIETORS of British Patent No. 669423 for "Anchoring means for the flexible diaphragms of shape-forming devices" will grant Licences or will sell the entire British Patent Rights. Replies to Bromhead & Co., Chartered Patent Agents, 376/379 Strand, London, W.C.2. 225-59

PRODUCTION CAPACITY AVAILABLE

BRIGHTON LAMINATIONS LTD. have, owing to extensions, capacity for manufacturing the following:—Vacuum formed Rigid P.V.C. Acetate and Polystyrene. Fibre and Glass Cloth laminates. Rigid P.V.C. to Rigid P.V.C. Printed laminates. Thermosetting industrial and decorative laminates. Printed Circuits on thermosetting laminates. Portslade, Brighton, Sussex. Hove 47177. 225-7

METALLIZATION OF PLASTICS.
SPECIALIST METALLIZERS TO THE MOULDING TRADE.
HAVE IMMEDIATE PLATING CAPACITY AVAILABLE FOR MOULDINGS IN POLY ACETATE, ETC.
Wide range of brilliant finishes.
100% adhesion and rock-hard surface.
Large or small run-offs. Samples a pleasure.
PEREIDEX METALLISATION, LTD.,
31D STATION ROAD,
WORTHING.
Phone, Worthing 4163.
LONDON OFFICE, PAD 6085. 225-36

CAPACITY AVAILABLE. Injection Moulding capacity available from 2–16 oz. machines. Customers moulds to be provided. Box P259, care of "Plastics." 225-26

CAPACITY AVAILABLE for manufacturing compression and injection moulds, together with jigs and general engineering to customers' own designs, or alternatively, designed by us. Inquiries for same will receive prompt attention. Elloid Engineering Co., Ltd., Goodacre St., Mansfield, Notts. Phone, Mansfield 2614. zzz-299

DIESINKING. Capacity available, plastic moulds, die casting dies, etc., top-class work. Russell Engineering Co., Russell Rd., Croydon. 227-1188

INJECTION MOULDING CAPACITY. Inquiries invited, 3 and 6 oz. machines, first-class toolmaking facilities included or customers' own moulds used. Box P2422, care of "Plastics." 226-1204

"KELLER" DIE-SINKING
CAPACITY AVAILABLE WITH
REASONABLE DELIVERY.
UNIVERSAL TOOLS LTD.,
TRAMWAY PATH, MITCHAM, SURREY.
Phone, MITcham 6111-2. 225-1

Production Capacity Available (contd.)

INJECTION MOULDINGS by I.O.G. Industries, Ltd., 41 Marshgate Lane, Stratford, E.15. Maryland 2804. 232-1182

REPETITION in Ebonite, Erinoid, etc. Capstan lathe work. Temple St., Rugby. Phone 4059. 235-1208

SHORT RUNS A SPECIALITY, LONG RUNS A PLEASURE. Low mould cost and overheads. Injection capacity and technical knowledge at your service. Westminster Plastics, Temple Works, 41 Old Church Rd., Chingford, E.4. Silverthorn 7927. 235-1207

DINES PRODUCTS, Whitehall Lane, Grays, Essex, for injection mouldings. 235-1209

CHIPPING OF PLASTICS AND GRINDING, screening, mixing and drying of all raw materials undertaken for the trade. Crack Pulverizing Mills, Ltd., Plantation House, London, E.C.3. Man 4405. zzz-0302

ELCO PLASTICS, LTD.,
HIGH WYCOMBE,
BUCKS.
A.I.D.-APPROVED.
MOULDERS, INJECTION COMPRESSION,
TRANSFER, SIDE RAM.
HIGH WYCOMBE 1921-2. zzz-311

INJECTION MOULDINGS on 1 oz. machine, prototype work accepted. Box P2455, care of "Plastics." zzz-313

INJECTION MOULDINGS IN THERMOPLASTICS. Moulding in styrene acrylics and acetate. Design and tool room facilities available for mould construction. Inquiries invited. J. and E. Courtenay, Ltd., 138 Stratford Rd., Birmingham, 11. 226-1184

INJECTION MOULDING CAPACITY available. Our speciality is the production of very small articles in polystyrene.
A. E. Stokes, rear of 128 Capworth St., Leyton, London, E.10. Leytonstone 3707. 229-1210

INJECTION MOULDINGS AND PLASTIC COVERING IN ACETATE ALKATHENE, P.V.C. POLYSTYRENE AND DIAKON.
Machined Parts in Brass, Steel and Plastics.
We solicit your inquiries.
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TRENT VALLEY WORKS,
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KINGSTON PLASTICS, LTD., Unity Works, Union St., Kingston-on-Thames. Manufacturers of virgin and second-grade cellulose acetate moulding powders, matched to customers' own requirements for colour and flow. Customers' own waste also reprocessed to specified requirements. Sorting and grinding, incorporating magnetic separation of metallic particles of all thermoplastics undertaken. Phone, Kingston 8405. 225-01174

PINNACLE PLASTICS, LTD., have immediate capacity available for all types of injection moulding. Write 31 Guildford St., Luton. Phone 1010. 228-1193

PLASTICS (MANCHESTER), LTD.,
BRITAIN'S LEADING STOCKISTS AND DISTRIBUTORS.
SPECIALISTS IN
FABRICATION, INJECTION MOULDING AND ENGRAVING.
11 WHITWORTH STREET,
MANCHESTER, 1.
Central 7081-2 and Central 1000. zzz-308

POLYSTYRENE AND CELLULOSE ACETATE INJECTION MOULDINGS up to 2 oz. Reliable service. Latest-type machines. Keen co-operation on new lines. W. H. Adamson Plastics, Ltd., 39 Hedley St., Maidstone. 225-1175

Production Capacity Available (contd.)

VACUUM FORMED PLASTICS. Facilities for design development, fabricating and printing. B. T. Bennett & Co., 449 Alexandra Avenue, Harrow, Middx. Field End 6755. 236-1219

TUBE LAMINATION AND ENGINEERING, LTD.,
HIGH WYCOMBE,
BUCKS.
MAKERS OF S.R.B.P. TUBE "LAMTUF."
LIGHT ENGINEERS.
HIGH WYCOMBE 1921-2. zzz-312

VISIJAR LABORATORIES, LTD.,
THE LEADING CRAFTSMEN IN
"PERSPEX."
PROTOTYPE AND REPETITION.
OFFICIAL I.C.I. STOCKISTS "PERSPEX."
SHEET, TUBE, ROD.
STOCKISTS AND FABRICATORS OF "FORMICA."
149 LONDON ROAD, CROYDON, SURREY.
Phone, Croydon 8228 (two lines). zzz-307

COMPRESSION MOULDING capacity available on fully automatic presses. Long runs of small mouldings required, up to ¾ oz. weight and 2½ in. max. diameter. Quotations at keenest prices on request. Box P2513, care of "Plastics." 225-43

PRODUCTION CAPACITY WANTED

PROGRESSIVE MANUFACTURERS seek further injection moulding capacity up to 8 oz. continuous work throughout the year, essential for assembly to be undertaken. Full details to Box P2416, care of "Plastics." 226-1202

COMPRESSION MOULDING CAPACITY required for long runs of small mouldings from existing 6- and 12-impression tools requiring 70/100-ton presses. Prompt payment and permanent business to firms able to quote keen prices. Write details of capacity to Box P2411, care of "Plastics." 225-1201

BRUSH MANUFACTURER interested to contact plastics firm able to supply polythene backs for domestic brushes. Box P2449, care of "Plastics." 225-1198

RAW MATERIAL

ALWAYS LARGE STOCKS OF
CASEIN
RODS, TUBES AND SHEETS.
PERSPEX
SHEETS UP TO 1 IN. THICK.
CELLULOSE ACETATE
CATALIN RODS.
S.R. (PLASTICS), LTD.,
93 ALDERSGATE STREET, E.C.1.
Phone, Monarch 4686. 233-1189

PLASTICS (MANCHESTER), LIMITED,
BRITAIN'S LEADING STOCKISTS
OF
PERSPEX SHEET, ROD, TUBE,
11 WHITWORTH STREET,
MANCHESTER, 1.
Central 7081-2 and 1000. zzz-309

VIRGIN CELLULOSE ACETATE MOULDING POWDER, surplus to requirements—
3,702 lb. Orange
3,570 lb. Maroon
3,662 lb. Blue
4,440 lb. Red
400 lb. Green
Prepared to sell below market prices.
Apply with offers to Universal Metal Products Ltd., Salford, 6. 225-12

WE SUPPLY polyethylene, polystyrene, scraps and reprocessed film waste, vinyl resins, all kinds of chemicals. Inquiries solicited. N. V. N. Jacobson and Co., 20 Hacquartstraat, Amsterdam. 229-1211

Raw Material (contd.)

PERSPEX, Formica, Waretite, Traffolyte Eng., sheet. Specialists in cut sizes. Immediate delivery.
F. J. Bly and Co., Ltd., Empire Arcade, 370 Upper St., Angel, N.1. Can 5242-3. zzz-310

CELLASTOID FLUORESCENT SHEETS 60/000 new. To clear. Box P2517, care of "Plastics." 225-57

AVAILABLE, 20 tons black polythene granules. Reasonable offer accepted. Box P1935, care of "Plastics." 225-50

POLYTHENE FILM SCRAP, perfectly clean, several tons for sale. Please write Box P2442, care of "Plastics." 225-56

CUEX, LTD., can offer all at prices well below current list:—
Polystyrene.
Cellulose acetate.
Polyethylene.
P.V.C.
Polyvinyl butyral.
Perspex and Diakon.
Send now for details.
Cuex, Ltd., 270 Corporation St., Birmingham. Central 5474. 225-48

LARGE QUANTITY of printed polythene film available. Please contact, Box P1936, care of "Plastics." 225-51

POLYSTYRENE, REGROUND, high impact, several tons light colour for disposal. Please ask for particulars. Box P2431, care of "Plastics." 225-54

RAW MATERIAL WANTED

DO YOU HAVE ANY PLASTIC SCRAP TO SELL ? Or are you looking for some to buy? Then contact Michael St. Stevens, Ltd., Keswick Rd., S.W.15. Phone, Vandyke 3345-6. zzz-303

ERLANOS, LTD., 93 Aldersgate St., E.C. (Monarch 4686), require Perspex and cellulose offcuts and scrap, clear and coloured; highest prices paid. 229-1159

PROMPT CASH OFFERED for virgin and reprocessed cellulose acetate and polystyrene. Give manufacturer's name and backing. Box P873, care of "Plastics." zzz-306

P.V.C. GARMENT AND HANDBAG OFFCUTS wanted. We collect and pay cash. Brockwell Plastics, Ltd., 50 Hollingbourne Rd., S.E.24. zzz-305

SURPLUS STOCKS of thermosetting and thermoplastic moulding powders wanted. Send details. Box P1727, care of "Plastics." zzz-297

WANTED, large regular supplies of nylon scrap shaving. Hugh Kershaw, Oxenhope, Keighley. 226-1183

WANTED, Polythene scrap. Write to Box P221, care of "Plastics." zzz-322

WANTED, plastic scrap. Send samples, details, price, etc. Box P2448, care of "Plastics." 225-34

URGENTLY REQUIRED, minimum 10 tons medium hardness green p.v.c. compound, varying shades of green accepted and if in good condition scrap material will be considered. Box P2447, care of "Plastics." 225-45

DIAKON ACRYLIC SCRAP. We buy large and small quantities and pay prompt cash. Send your offers immediately to J. W. Nash and Co., Ltd., 27 Beethoven St., W.10. 228-49

POLYTHENE, NATURAL, in any form and quantities required. Please offer with particulars to Herbert Connor, Ltd., 120 Beaufort Park, London, N.W.11. 225-55

REPRESENTATION

MEE TAK COMPANY, 29 Jervois Street, Hongkong, Importers/Wholesale-dealers, wish to represent manufacturers of upholstery leathercloths, P.V.C. sheetings, cellulose acetate and lampshade materials. 225-63

Representation (contd.)

A SALES REPRESENTATIVE is required for the energetic sales development of "UNDULITE," the new roofing material, by Ashdowns Limited, leading Plastics Manufacturers, whose Works is situated in St. Helens. Applications are invited from men between 30 and 40 years of age who have sound established connections with the building trade and with architects. The person selected to fill this vacancy will be required to operate and live in either the London area/or in Southern England. Applicants are invited to send details of their education and experience to the Personnel Liaison Officer, Pilkington Brothers Limited, St. Helens, Lancs (of whom Ashdowns Limited is a Subsidiary Company), quoting Ref.: "U." 225-14

SALES

Injection/Extrusion

SENIOR SALES EXECUTIVE

with wide experience in Plastics and with good connections required on part-time or full-time basis to develop sales of plastic products and components in consumer and industrial fields. Advertisers are Injection Moulders of long standing now planning expansion, including installation of extrusion plant. Kindly state experience. Replies will be held in confidence. Box P2518, care of "Plastics." 225-58

SITUATIONS VACANT

ASSISTANT FOREMAN, fully experienced in Injection Moulding techniques, required for Moulding Department of a rapidly expanding organisation shortly moving to new and larger premises. Must be able to control personnel. Good salary and prospects of advancement. Superannuation Scheme. Apply by letter in first instance, giving full details of age and experience to Hughes Brushes Ltd., 240 Bath Road, Slough, Bucks. 225-19

A SALES EXECUTIVE is required by Ashdowns Limited, leading Plastics Manufacturers whose Works is situated in St. Helens, for the energetic sales development of plastic products manufactured by a vacuum forming process. Applications are invited from men aged between 28 and 40 years who are keen on sales and interested in the design and development of new products and their marketing to many different outlets in industry and the distributive trades. Experience of product and marketing development would be advantageous but, above all, the successful applicant must possess initiative and imagination, be of good appearance and capable of carrying responsibility. He will be required to travel the country in the course of his duties. Applicants are invited to send details of their education and experience to the Personnel Liaison Officer, Pilkington Brothers Limited, St. Helens, Lancs (of whom Ashdowns Limited is a Subsidiary Company). 225-3

ASSISTANT TO SALES MANAGER required for Industrial Department of Plastic Injection Moulders. Age 25/35. Some technical background preferable. Pleasant working conditions. Good salary and prospects for successful applicant. Write full particulars to Stewart Plastics Ltd., Purley Way, Croydon, Surrey. 225-4

ASSISTANT ENGINEER for the Engineering and Tool-room Section of their Development Department is required by British Industrial Plastics Limited, Oldbury. Toolmaking and practical engineering experience over a minimum of six years is essential and H.N.C. or equivalent is desirable. This vacancy offers good prospects and Pension and Life Insurance Scheme.
Apply in writing giving fullest details of education and experience to: Personnel Manager, British Industrial Plastics Limited, Oldbury, Birmingham. 225-6

A VACANCY HAS ARISEN in the Plastics Department of a progressive research and development minded company in the South London area. Applicants should possess a degree in chemistry or physical chemistry, have completed National Service, and be not more than 26 years of age. Previous experience with plastics would be an advantage, but not essential. Please write giving full particulars, to Box P242, care of "Plastics." 225-1199

DEPARTMENTAL MANAGER required for interesting work on Glass Reinforced Laminates. Good prospects. Salary and Pension Scheme. Apply Box P256, care of "Plastics." 225-29

Situations Vacant (contd.)

DESIGNER-DRAUGHTSMEN, aged about 30, required for development work on machinery for plastics industry. General capability and initiative more important than wide experience. Good prospects, five-day week, canteen facilities, contributory pension scheme. Salary according to proved ability.
Apply: R. H. Windsor Limited, Leatherhead Rd., Chessington, Surrey. Epsom 5631. 225-9

DETAIL-DRAUGHTSMEN required for work on machinery for the plastics industry. General capability and initiative more important than wide experience. Good prospects, five-day week, canteen facilities, contributory pension scheme. Salary based on A.E.S.D. scales.
Apply: R. H. Windsor Limited, Leatherhead Rd. Chessington, Surrey. Epsom 5631. 225-10

DEVELOPMENT ENGINEER with experience of plastic compression moulding required by electrical manufacturers. Position offers scope for original work on new projects. Location London, E.18. Write Box P2427, care of "Plastics." 225-1205

ENGINEER or **PHYSICIST** required by N.C.B.'s Mining Research Establishment, Worton Hall, Isleworth, Middlesex, for research on mechanics of belt conveyors and relevant properties of belting and belt materials, to improve performance and life of belts on underground coal conveyors. Good honours degree (or equivalent) in mechanical engineering or physics required, preferably with some research experience. Much of the work is carried out initially in the laboratory, but underground trials may be involved later. Appointment (superannuable), according to qualifications and experience, within inclusive scales as either Scientist 2 (£991–£1,390 male) or Scientist 3 (£617–£1,124 male).
Write, with full particulars of age, education, qualifications and experience, to National Coal Board, at above address, marking envelope SS/276, before July 12, 1956. 225-8

EXPERIENCED MOULDING SHOP FOREMAN required for night shift. Must have tool setting knowledge 1 to 8 oz. machines. Box P258, care of "Plastics." 225-27

FOREMAN required, to take complete charge of machine shop, by Company engaged in moulding Thermo Plastic materials. Sound experience of Injection Moulding essential. Good salary, staff bonus and pension scheme in operation. Social club and canteen facilities. Please apply Box P257, care of "Plastics." 225-28

FOR EMPLOYMENT IN CANADA.

CHEMISTS FOR FUNDAMENTAL RESEARCH IN CELLULOSE AND RELATED FIELDS.

A large research organization in the vicinity of Montreal serving one of Canada's largest industries requires:—

2 PHYSICAL CHEMISTS
2 ORGANIC CHEMISTS

with Ph.D. degrees from an accredited university.

Previous experience in cellulose research not necessary, but would be an advantage. A thorough training in the fundamentals of chemistry is expected.

Applicants should be male, 23–30 years old and in good health. They should have a pleasant personality, possess initiative and energy, and be willing to accept responsibility.

Laboratories are modern and well equipped; present staff numbers about 150. Starting salary will depend on education and experience. Travelling expenses up to $350 will be paid.

The Company maintains insurance and retirement plans and offers wide social and recreational facilities, i.e. golf, tennis, skiing, curling, angling, etc.

Apply in writing to Box P2441, giving full particulars of education, experience, interests; also attach a photograph. 226-1197

PHYSICAL CHEMIST. A Physical Chemist is required immediately by B.X. Plastics Ltd., to work at the Research Station, Lawford Place, Nr. Manningtree, Essex, in the Chemical Research and Development Department. The successful candidate will be required to initiate a programme of work in a new and interesting field of high polymer research, and a good background knowledge of polymer chemistry would be an advantage. Applications stating age, qualifications and experience, should be addressed to the Personnel Manager, B.X. Plastics Ltd., Brantham Works, Nr. Manningtree, Essex. 226-1218

Situations Vacant (contd.)

MOULDMAKERS REQUIRED. Highest rates of pay for really good men. Chudleigh, Heathman's Yard, Parsons Green, S.W.6. Renown 1370. 225-33

PROGRESSIVE COMPANY requires capable assistant for nylon moulding and processing department recently formed. Ideal opportunity for young man wishing to progress, who should preferably have some training or experience in this and kindred materials. Howard Clayton-Wright, Ltd., Wellesbourne, Warwick. 225-1206

ROOTES MOULDINGS LIMITED, Oxford Avenue, Slough, require Sales Representative. Age 30/40. Plastics Moulding Sales experience essential. Good salary, motor car, and expenses. Permanent position with wide scope and prospects. Write in confidence stating age, experience and salary required, etc. 225-13

SALES REPRESENTATIVE with selling experience of Laminated Bakelite and Micanite products required by leading manufacturers in the North of England. This position is permanent and pensionable and offers good prospects.

Applicants should apply in writing, stating age, qualifications and previous experience, to Box P253, care of " Plastics." 225-22

SENIOR RUBBER OR PLASTICS TECHNOLOGIST required for laboratory in London area. A.I.R.I. or equivalent. Experience in the cable industry desirable but not essential. Knowledge of synthetic rubbers, polythene and Nylon an advantage. Write in confidence giving details of age, experience, etc., to Box P2421, care of " Plastics." 225-1203

SHORT BROTHERS & HARLAND LIMITED
require
SENIOR PRODUCTION DEVELOPMENT ENGINEER

for interesting work on reinforced plastics with regard to aircraft components, jigs and fixtures, etc.

The work in the main is experimental and offers considerable scope to a person of integrity and ability.

Applicants should have a wide knowledge of plastics techniques, with particular reference to casting and laminating thermosetting materials.

Pension scheme, assistance with housing in Northern Ireland and removal expenses thereto.

Apply in the first instance to Personnel Manager, P.O. Box 241, Belfast, stating qualifications, previous experience, age, etc., and quoting Ref. P.22. 225-20

WANTED Sales and Development Engineer who should have knowledge of Mixing, Calendering and Extrusion of Rubber and Plastic materials. Apply in writing to Francis Shaw & Co. Limited (Dept. FBS), Corbett Street, Manchester 11. 226-1217

THE METAL BOX COMPANY LTD. requires in London Plastic Injection Moulding Tool Designers and Development Engineers. Suitable experience essential and work includes novel development requiring design imagination. Prospects for advancement are good and salaries are paid appropriate to experience. Apply to Head of Staff Division, The Metal Box Company Ltd., The Langham, Portland Place, London, W.1, quoting reference Dev/1. 225-11

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD., Cable Manufacturers, require a Research Assistant preferably with experience in plastics work, e.g. the processing and extrusion of polythene, polyvinychloride and other thermoplastics. Inter-B.Sc. degree or equivalent. Salary range £543–£650. Opportunities exist for further education and advancement. All posts pensionable. Five-day week and all welfare facilities. Write details to Personnel Manager, Telcon Works, Greenwich, S.E.10. 225-2

TECHNICIANS required by company in the North East engaged in the production of thermosetting moulding materials and allied products. Applicants should have a good practical experience of moulding processes and tool design and preferably conversant with Quality Control methods. Apply Box P251, care of " Plastics." 225-17

Situations Vacant (contd.)

DESIGN DRAUGHTSMAN. E. K. Cole, Ltd., Southend-on-Sea, have a vacancy in their Plastics Division for a mould design draughtsman. Experience of injection, transfer and compression mould design essential. Write stating age, qualifications and experience, to Personnel Manager. 225-40

EXPERIENCED MAN needed to take charge of Extruder Mixer. Colour matching experience desirable, but not essential. Ideal opening for ambitious man in expanding business. Write giving full details of experience, salary required, etc., to Box P2512, care of " Plastics." 225-42

GENERAL MANAGER
REQUIRED BY
LARGE INDUSTRIAL GROUP
WITH INTERESTS IN THE
UNITED KINGDOM AND ABROAD.

HERE IS THE OPPORTUNITY OF A LIFETIME FOR A MAN OF STRONG PERSONALITY, POSSESSING INITIATIVE AND A DETAILED KNOWLEDGE OF THE PLASTIC EXTRUSION INDUSTRY.

APPLICANTS SHOULD HAVE HELD SIMILAR OR SENIOR ADMINISTRATIVE POSITIONS PREVIOUSLY.

PENSION SCHEME, HOUSING ACCOMMODATION PROVIDED IF NECESSARY, SALARY COMMENSURATE WITH EXPERIENCE.

ONLY APPLICANTS SELECTED FOR INTERVIEW WILL BE NOTIFIED.

Applications in confidence, giving age, education, experience, salaries earned and salary required, to Box P2450, care of " Plastics." 225-47

PLASTICS TECHNOLOGIST with proved experience in P.V.C. compounding and testing methods required to take control of physical testing laboratory. The post is progressive and starting salary will be according to experience. There is a contributory pension scheme and excellent canteen facilities. Applications in writing to Vinyl Products Ltd., Butter Hill, Carshalton, Surrey. 226-1220

PLASTICS TECHNOLOGIST with proved experience in P.V.C. compounding and testing methods required to take over control of physical testing laboratory. Salary according to experience. Contributory pension scheme and canteen. Submit full details to Vinatex, Ltd., Devonshire Rd., Carshalton, Surrey. 225-35

PLASTICS DEVELOPMENT ENGINEER required in managerial-technical capacity. Practical experience all branches thermoplastics to aircraft standards essential. Outer West London area. Box P2419, care of " Plastics." 225-32

PRODUCTION MANAGER required. Experienced in all types of Plastics Moulding. Excellent opportunities. North London. Write with full details of experience, salary required, etc., to Box P2516, care of " Plastics." 225-39

THE PLASTICS INSTITUTE has vacancy for a full-time male Secretary to the Council, whose duties include responsibility for staff at Head Office, attendance at Council and Committee meetings, Minutes, Records, etc. Young A.C.I.S. might be suitable. Salary about £1,000 per annum according to age and experience. Pension scheme available.
Applications to be addressed to Chairman of Council, Plastics Institute, 6 Mandeville Place, London, W.1, endorsed " Secretarial Vacancy." 225-41

JUNIOR ENGINEER. May & Baker Ltd., Dagenham, Essex, require in their Plastics Production Division, a mechanical engineering graduate, aged 22/25, to assist in the development of new products and eventually to assume control of their manufacture. Contributory pension scheme; five-day week. Apply initially in writing, quoting Reference No. 122, to the Personnel Officer. 225-53

Situations Vacant (contd.)

TOOLMAKER REQUIRED. First class man with initiative. Capable of making and developing new machinery in connection with P.V.C. Products. Very interesting work. Good salary for right man. Apply Box P2514, care of " Plastics." 225-44

A VACANCY HAS ARISEN in the Plastics Laboratory of a research and development-minded, progressive company in the South London area. The work is both novel and interesting, and would satisfy the creative ability of anyone keen and energetic. Minimum qualification B.Sc. degree, with a leaning towards chemistry. Applicants should be of British nationality, not more than 27 years of age, and have completed their Military Service. Wages according to qualifications and experience. Write to Box P228, care of " Plastics." 225-37

AN EXPERIENCED MAN required, capable of taking charge of a small compression moulding shop. Within 40 miles of London. Well-paid and permanent position. Write stating full details of experience. Box F2220, care of " Plastics." 225-61

AN EXPERIENCED MAN required to take charge of mould shop. Promotion to production controller envisaged. Therefore experience of tool-making and administration an advantage. South-west London area. Box P2520, care of " Plastics." 225-63

TOOLMAKERS AND MILLERS required, used to plastic moulds; first-class craftsmen need only apply, who will be offered a high rate. Apply: " Seaforth," Watchett Works, Oakhurst Rd., Southend-on-Sea, Essex. 225-60

ASSISTANT MOULDING SHOP FOREMAN required with experience of injection and compression techniques. Service knowledge of Peco and Lester machines an advantage. Write stating age and full experience to Box P2429, care of " Plastics." 225-38

EXPERIENCED INJECTION MOULDING SHOP FOREMAN for night work. Must have tool setting knowledge. Write full details Box P2420. 225-30

SITUATIONS WANTED

ENERGETIC REPRESENTATIVE requires situation London and S. Counties. Good knowledge plastic moulds, mouldings, engineering background, car available. Box P2521, care of " Plastics." 225-x6500

WORKS MANAGER, thoroughly experienced, compression and injection, seeks change. Good organizer. Willing to build up small company. Box P2515, care of " Plastics." 225-x6168

TIME RECORDERS

FACTORY TIME RECORDERS. Service rental. Phone, Hop 2239. Time Recorder Supply and Maintenance Co., Ltd., 157–158 Borough High St., S.E.1. 233-1190

BOOKS AND PUBLICATIONS

MOULDS FOR PLASTICS, by W. M. Halliday. Meets the needs of both mould designer and toolmaker. Discusses design, construction, operation and maintenance problems in the light of practical experience. Illustrated. 286 pages, 30s. net from booksellers, or 30s. 10d. by post from the publishers, Temple Press Ltd., Bowling Green Lane, London, E.C.1. zzz

PLASTICS, SCIENTIFIC AND TECHNOLOGICAL (3rd Edition), by H. R. Fleck. A recognized standard work on the chemistry and technology of plastics. Illustrated. 400 pages, 40s. net from booksellers, or 41s. 3d. by post from the publishers, Temple Press Ltd., Bowling Green Lane, London, E.C.1. zzz

CELLULOSE ACETATE PLASTICS, by Vivian Stannett. A complete technical survey of one of the most popular and adaptable products of the plastics industry. Illustrated, 284 pages, 30s. net from booksellers or 31s. by post from the publishers, Temple Press Ltd., Bowling Green Lane, London, E.C.1. zzz

THE THEORY OF POLYMERIZATION, by H. R. Fleck. A full explanation in simple language with examples, calculations and exercises of this fundamental aspect of the chemistry of plastics. Illustrated, 144 pages, 10s. 6d. net from booksellers, or 11s. by post from the publishers, Temple Press Ltd., Bowling Green Lane, London, E.C.1. zzz

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The modern housewife owes a debt of gratitude to 'Alkathene'. Houseware made from this outstanding plastics material has revolutionised her work in the home. 'Alkathene' is extremely light, hardwearing and virtually unbreakable. It has a smooth, hygienic surface that is easily washable and it comes in a very wide range of attractive colours, to suit any colour scheme. 'Alkathene' is easy and economical to mould on standard injection moulding equipment. Mouldings of excellent finish can be obtained at a high output rate. In fact, 'Alkathene' is an ideal material for best-selling houseware.

'Alkathene' is the registered trade mark for the polythene made by I.C.I.

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

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one for the record

Erinoid polystyrene CP.20 for COLLARO

For the moulded components of their tape transcriptors and record players, Collaro Ltd. use Erinoid CP.20 grade. This modified polystyrene of high impact and flexural strength moulds easily to give an excellent surface finish. The mouldings are well able to withstand the rigours of continuous handling. Erinoid CP.20 grade is available as moulding powder, sheet and extruded sections.

Erinoid polystyrene is manufactured by

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